SOIL SURVEY

Sacramento Area California

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UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

FARMERS who have lived in one locality for a long time know about differences among soils on their own farms and on the farms of their immediate neighbors. What they do not know, unless a soil survey has been made, is how nearly their soils are like those at experiment stations or on other farms where experience has been gained with new or different farm practices or enterprises. Farmers of the Sacramento Area can avoid some of the risk and uncertainty involved in trying new crop and soil management practices by using this soil survey report, for it maps and describes the soils of their area and allows them to compare the soils on their farms with soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

All the soils of the Sacramento Area are shown on the soil map accompanying this report. In using this map, first locate the boundaries of your farm by referring to roads, streams, dwellings, and other landmarks shown on the map. The next step is to identify the soils on your farm. Suppose, for example, you find on your farm an area marked with the symbol Hp. Look among the colored rectangles in the margin of the map and find the one with Hp printed on it. This identifies Honcut very fine sandy loam, nearly level. All areas of this soil, wherever they appear on the map, have the same symbol and color.

What is Honcut very fine sandy loam, nearly level, like; for what is it now used; and how should it be used? For this information turn to the section on Soil Descriptions, where each soil is discussed.

How productive is this soil? The answer will be found in the section on Relative Suitability of the Soils for Agriculture. In table 5 the suitability of all the soils is given in relative descriptive terms, and in table 6 these terms are converted into yield ranges for principal crops.

SOILS OF THE AREA AS A WHOLE

If a general idea of the soils of the area is wanted, read the sections on Soil Series and Their Relations. This tells where the principal kinds are found, what they are like, and how they are related to one another. Then study the soil map and notice how the different kinds of soils tend to be arranged in different localities. These patterns, emphasized by colors on the map, are associated with well-recognized differences in type of farming and land use.

A newcomer who considers purchasing a farm in the area will want to know about the climate; the types of farming practiced; the availability of transportation, markets, water supplies, and electricity; the industries; and the size and location of cities and villages. This information will be found in the sections on Agriculture and on General Nature of the Area.

Students and others interested in how the soils of the area were formed and how they are related to the great soil groups of the world should read the section on Morphology and Genesis of Soils.

This publication on the soil survey of the Sacramento Area, California, is a cooperative contribution from the—

SOIL CONSERVATION SERVICE

and the

UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

SOIL SURVEY OF THE SACRAMENTO AREA, CALIFORNIA [1]

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United States Department of Agriculture in cooperation with the University of California Agricultural Experiment Station

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[1] Field work for this survey was done while the Division of Soil Survey was a part of the Bureau of Plant Industry, Soils, and Agricultural Engineering. It was transferred to the Soil Conservation Service on November 15, 1952.

THE SACRAMENTO AREA owes its settlement to the discovery of gold and development of the mining industry but is now an agricultural area producing livestock, grain, fruits, nuts, and truck crops. Packing and processing of these food products provide employment for the urban population. Agriculture might be even further developed by extending irrigation to some localities and draining others. To help the farmer meet these and other problems, the United States Department of Agriculture and the University of California Agricultural Experiment Station conducted a cooperative survey, the results of which are reported here. Field work was completed in 1941. Unless otherwise mentioned all statements in the report refer to conditions in the area at that time.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

The Sacramento Area is in the southeastern part of the Sacramento Valley. It includes all of Sacramento County, except the small area between the confluence of the Sacramento and the San Joaquin Rivers, which was surveyed in 1935 (*5*).[2] It is bounded by Sutter and Placer Counties on the north, El Dorado and Amador Counties on the east, and Dry Creek and the North Fork Mokelumne River on the south. Its boundary along the west side (fig. 1) is formed by the Sacramento River. The approximate total extent is 562,560 acres.

Sacramento, the largest city, is not only the seat of the county but also the State capital. Berkeley is approximately 65 miles southwest of Sacramento; Los Angeles, 375 miles southeast; and San Diego, 490 miles southeast.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The Central Valley of California extends for about 420 miles from north to south between the Sierra Nevada Mountains and the Coast Range; the southern part is known as the San Joaquin Valley, and the northern part as the Sacramento Valley. The average width of this great valley is about 40 miles. From an elevation of 569 feet at Redding (in Shasta County) in the north and 489 feet at Bakersfield (in Kern County) in the south, the valley floor drops to about 25 feet at Sacramento. The highest recorded elevation in the survey area, 800 feet, occurs about 2 miles north of White Rock in the northeastern corner. The only outlet for drainage from this valley and its water-

[2] Italic numbers in parentheses refer to Literature Cited, p. 101.

shed is through Carquinez Strait into San Pablo and San Francisco Bays.

The geology of the valley is closely associated with the uplift and subsequent erosion of the Sierra Nevada. The valley was formed as a result of the tilting of a segment of the earth's crust, and at times it was a land-locked sea, where the debris eroded from the mountains was sorted by the sea water.

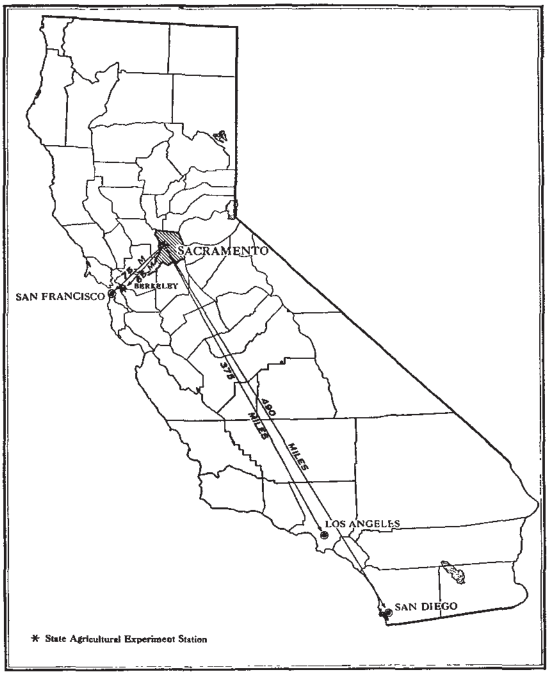

FIGURE 1.—Location of the Sacramento Area in California.

Natural drainage ranges from excessive in the eastern low foothills region to restricted or poor in the nearly level central and western parts. The western part has to depend largely on artificial drainage provided by ditches. Water in these ditches is pumped over levees into the Sacramento River or various sloughs. The major streams draining the county originate outside of its boundaries to the east. The Cosumnes and American Rivers, the major streams, both head in the high Sierras and terminate along the west side of the area, where they empty into the North Fork Mokelumne and the Sacramento Rivers.

CLIMATE

The climate of the Sacramento Area is characterized by hot dry summers and cool moist winters. The lack of major physiographic differences results in a nearly uniform climate for the entire area. Table 1 gives monthly, seasonal, and annual temperature and precipitation at Sacramento.

The average annual precipitation for Sacramento, over a period of 102 years, is 18.02 inches. The greatest precipitation falls in the winter months, and the least in summer. Except for rarely occurring local showers of short duration, the months of July and August are rainless. Irrigation is necessary for most cultivated crops growing during summer. Grain, which uses the moisture of the winter months and matures in May, is an exception. The quantity and quality of the range forage in the eastern half of the area depend not so much upon the total rainfall as upon the seasonal distribution. Usually, the rains are gentle enough for the soils to absorb a maximum quantity of moisture. Violent thunderstorms are extremely rare. Snow seldom falls in the valley and quickly melts when it does. Snow in the high Sierras supplies much of the water for summer irrigation.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Sacramento, Sacramento County, Calif.*

[Elevation, 25 feet]

Month	Temperature [1]			Precipitation [2]		
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
December	46. 2	69	24	3. 03	2. 11	10. 45
January	45. 8	72	19	3. 72	1. 09	3. 43
February	50. 1	80	21	3. 09	1. 76	4. 46
Winter	47. 4	80	19	9. 84	4. 96	18. 34
March	54. 3	85	29	2. 57	. 34	8. 14
April	58. 1	91	34	1. 51	. 76	4. 32
May	63. 3	103	37	. 77	. 30	. 06
Spring	58. 6	103	29	4. 85	1. 40	12. 52
June	69. 4	111	43	. 15	(3)	1. 45
July	73. 2	114	47	0	(3)	0
August	72. 9	110	48	0	0	(3)
Summer	71. 8	114	43	. 15	0	1. 45
September	69. 3	107	41	. 38	0	. 60
October	62. 9	99	36	. 92	0	2. 01
November	53. 6	82	27	3. 18	. 36	0
Fall	61. 9	107	27	3. 18	. 36	2. 61
Year	59. 9	114	19	18. 02	[4] 6. 72	[5] 34. 92

[1] Average temperature based on 74-year record, 1878 to 1951; highest and lowest temperatures from 53-year record, 1878 to 1930.
[2] Average precipitation based on 102-year record, 1850 to 1951; wettest and driest years based on 82-year record, 1849 to 1932.
[3] Trace.
[4] In 1932.
[5] In 1884.

The prevailing summer winds come from the south; their average velocity is 7 to 9 miles per hour, though velocities of 47 to 51 miles per hour have been recorded. Hot, drying, north winds blow at intervals from late in spring to early in fall; they are one of the unpleasant features of the local climate. Velocities of 30 miles an hour are common, and considerable damage from dessication of orchards, field crops, and range plants frequently occurs. Tornadoes and damaging hailstorms are unknown.

Fogs occur frequently during the early winter months, especially in the western part of the area. Usually fog dissipates before noon, but it may remain uninterrupted for several days. The average relative humidity at noon for the Sacramento station is 45 percent in June, 43 percent in July, and 44 percent in August. It rises to 79 percent in December, and to 84 percent in January. The daily variation in temperature is usually as much as 25° to 40° F. for the hotter summer months, but during the winter it is much less. The excessive summer heat is usually moderated in the evenings by a cool breeze that originates on the seacoast and passes inward through Carquinez Strait to spread eastward and northward over the delta and adjacent regions.

The Sacramento station has recorded killing frosts as late as May 7 and as early as November 4, but the average length of the frost-free season is 308 days, or from February 5 to December 11. Few of the ordinary farm crops are endangered by frosts.

WATER SUPPLIES

In the rural areas water for household use and livestock comes almost entirely from wells, which are also the source of a considerable part of the irrigation water. Fair Oaks, Folsom, and Sacramento get water from the American River, whereas other towns of the area obtain their supply from the deep wells or other sources. Wells equipped with windmills supply water to livestock in the rangeland areas, and in recent years the number of small livestock reservoirs has greatly increased. Few springs occur within the area, and the flow in minor streams ceases late in spring.

Except for the Sacramento River along the west side, the area includes no streams or lakes of recreational importance. The nearby Sierras, however, offer possibilities for recreation and sports of many kinds at all seasons, and numerous deep waterways in the delta region a few miles south of Sacramento provide excellent boating and fishing.

VEGETATION

On the alluvial plains, which constitute the principal physiographic division of the area, annual grasses and associated low-growing herbaceous plants predominate. Some oak, cottonwood, and in places willow trees grow near or along the larger streams. In the foothills vegetation consists mainly of oak and digger pine trees and annual grasses. Brush covers places on steep slopes. In the alluvial basins where drainage is imperfect or poor, tules are common along natural or artificial drainageways. Reeds, sedges, other water-loving plants, some of the annual grasses, and associated plants grow in noncultivated areas. The type of vegetation in the basins largely depends on local drainage. Cottonwoods, willows, ryegrass, and in places dense growths of blackberry briers occur along the Sacramento River.

Plants in the following list were collected from a number of places throughout the area and identified shortly after completion of the survey. These names are not to be considered as a complete list of plants growing in the area. Rather, they represent the plants most commonly encountered.

TREES

Scientific name	*Common name*
Aesculus californica	California buckeye.
Pinus sabiniana	Digger pine.
Populus fremontii	Cottonwood.
Quercus douglasii	Blue oak.
Q. kelloggii	California black oak.
Q. lobata	California white oak.
Q. wislizenii	Interior live oak.

SHRUBS

Artemisia californica	California sagebrush.
Cephalanthus occidentalis	Buttonball bush.
Rhamnus californica	California buckthorn.
Rhus diversiloba	Poison-oak.

HERBS

Amaranthus graecizans	Tumbleweed.
Ambrosia psilostachya	Ragweed.
Brassica nigra	Black mustard.
Centaurea melitensis	Star-thistle.
C. solstitialis	Barnaby's thistle.
Chenopodium botrys	Jerusalem-oak.
Cichorium intybus	Chicory.
Convolvulus arvensis	Field bindweed.
Eriogonum nudum	Barestem eriogonum.
Erodium botrys	Big heronbill.
E. cicutarium	Alfileria.
Eschscholtzia californica	California-poppy.
Helianthus annuus	Common sunflower.
Lactuca serriola	Prickly lettuce.
Lepidium draba	Pepperweed whitetop, or peppergrass.
Lupinus bicolor	Bicolor lupine.
L. nanus	Sky lupine.
Madia elegans	Tarweed.
Medicago hispida	Burclover.
Melilotus alba	White sweetclover.
M. indica	Annual yellow sweetclover.

GRASSES

Cynodon dactylon	Bermuda grass.
Distichlis stricta	Saltgrass.
Echinochloa crus-galli	Barnyard grass.
Elymus triticoides	Wildrye.
Avena fatua	Wild oat.
Briza minor	Little quaking grass.
Bromus carinatus	California brome.
B. mollis	Soft chess.
B. rubens	Red brome.
B. rigidus	Ripgut.
B. secalinus	Cheat.
Festuca confusa	Fescue.
Hordeum murinum	Mouse barley.
Lolium multiflorum	Italian ryegrass.
Phalaris minor	Canarygrass.

EARLY HISTORY AND POPULATION

Sacramento, more than any other one city, played the key role in the early history of California after the Padres. It was founded in 1839 by Captain John A. Sutter, the first white settler in this region and county. The settlement he began was christened New Helvetia, but this was later changed to Sacramento, a name derived from the adjacent river. Settlers trickled in slowly until the discovery of gold at Coloma (in El Dorado County) in 1848 (*8*). The population since then has steadily increased and in 1950 was 137,572.

Sacramento County was formally organized in 1851 with boundaries about as they are today. California became a State in 1850, and the city of Sacramento, laid out in 1848, was selected as the permanent State capital. Because of its central location, the city benefited greatly by the volume of commerce brought first by the gold mines and later by industries and agriculture.

INDUSTRIES AND MARKETS

Most of the industrial establishments in and near Sacramento pack or process fruits, vegetables, meats, and dairy products. Also located in or near the city are a number of factories providing boxes, crates, and tin cans; flour, feed, and rice mills; and nut- and olive-processing plants. Two wineries are located at Florin, one at Mills, two near Perkins, and one a few miles northwest of Galt. The concentration of a wide variety of processing industries in and near Sacramento provides a ready market for much of the farm produce of the region. Raw products are drawn chiefly from a 50-mile radius. Milk is collected daily from all parts of the county. These industries affect the acreage and kind of crops planted.

Sacramento is a distributing center for much of the heavy equipment used in the mines and mills in the Sierras and for a considerable proportion of the farm machinery and hardware used throughout the interior valleys. Building materials, chemicals, electrical goods, and many other supplies are wholesaled from here. Two major railroads, the Southern Pacific and Western Pacific, have shops at Sacramento and Roseville (in Placer County).

TRANSPORTATION

The first railroad in the State, built in 1856, ran from Sacramento to Folsom. As more railroads were built Sacramento became the converging point for the transcontinental lines and the coast and valley railways.

Most of the transcontinental highway traffic through northern California passes through Sacramento, as does that from Los Angeles to Portland, Oreg. United States Highways Nos. 40 and 50, used by traffic to eastern cities, cross the Sierra Nevada to the east.

Local transportation requirements are met by a number of railroad lines and highways. United States Highways Nos. 40, 50, and 99, which converge at Sacramento, pass through the important agricultural parts of the area. All parts of the area are within reach of a network of paved or surfaced secondary roads, so that transportation of field crops and livestock is possible at any season.

Commercial truck lines and main or branch bus lines serve most of the communities. Freight can be shipped to San Francisco by water.

Transcontinental airlines use the facilities of the Sacramento municipal airport to bring mail and passenger service to this region.

SCHOOLS, FARM ORGANIZATIONS, AND IMPROVEMENTS

The rural areas of Sacramento County were served by 6 high schools at the time of survey. Each of the 60 rural school districts had 1 or more elementary schools. There were 18 elementary schools, 5 junior and 2 senior high schools, 1 junior college and one 4-year State college in Sacramento. The city schools offer night courses in many cultural, commercial, and industrial subjects. There are no tuition fees, and college credit is given for some courses. Adult attendance is encouraged.

One active rural organization is the Farm Bureau. Meetings are usually held in schoolhouses, community halls, or buildings owned by the farm center. The Grange and the Associated Farmers are other active rural organizations in the County. The Department of Agriculture and Land Grant colleges are represented by the county Farm Advisor, who disseminates information collected by these agencies and promotes better farming practices. Boys' and girls' 4–H Club work throughout the county is organized by the county Farm Advisor and his staff.

All farm homes except isolated ranches in the eastern part of the area have electric power which is used both in the home and to pump water for irrigation. The quality of farm houses in general is associated with the productivity of the soils; those on the shallow and hardpan soils usually are poorer than the others. This is not true within a radius of 15 miles of Sacramento, where homes are owned by city workers who derive little of their income from their small rural holdings.

AGRICULTURE

Largely because of differences in the climate and soils, agriculture in the Sacramento Area varies with the locality. The temperature range favors the growth of a wide variety of crops, although danger of winter frosts makes the growth of semitropical fruits like oranges uncertain. The somewhat cooler temperatures also cause the area to be unsuitable for cotton or raisin grapes. Prunes, however, are successfully produced and dried in this section. The chief form of agriculture in the foothills is livestock grazing. On the old alluvial plains and on some of the deeper upland soils extensive areas are planted to dry-farmed grain. On the deep, recent alluvial soils where intensive cultivation and irrigation are possible, farmers raise a variety of orchard fruits, nuts, and truck and field crops. In basin areas rice, other grain crops, and some truck and field crops are grown. One of the most important agricultural enterprises in the area is poultry raising. In this activity most of the poultry feed is produced on land not included in the poultry farms.

CROPS

The following pages contain a brief discussion of the important crops in the area. Sacramento County crop acreages in stated years are given in table 2, as compiled from United States census reports.

TABLE 2.—*Acreage of the principal crops and number of bearing fruit trees and grapevines in Sacramento County, Calif., in stated years*

Crop	1929	1939	1949
	Acres	*Acres*	*Acres*
Corn	4, 124	3, 133	5, 152
For grain	3, 006	2, 321	4, 211
Hogged, grazed, or cut for fodder or silage	1, 118	812	941
Small grains threshed:			
Barley	21, 763	27, 601	41, 224
Oats	10, 297	14, 092	10, 954
Sorghum, grain	840	4, 165	8, 530
Wheat	34, 521	31, 593	22, 527
All hay	31, 053	28, 119	45, 372
Alfalfa	12, 901	12, 141	18, 365
Clover and timothy, alone or mixed	33	1, 361	1, 931
Annual legumes cut for hay	88	149	(1)
Small grains cut green	15, 348	10, 737	20, 613
Other hay cut, including wild hay	2, 683	3, 731	4, 463
Beans, dry	10, 169	3, 650	5, 906
Hops	763	2, 042	(1)
Rice	677	1, 536	9, 332
Sugar beets	665	10, 235	11, 272
Truck crops for sale:			
Asparagus	23, 578	9, 218	1, 951
Beans, snap or string	1, 952	36	7
Beets, table	595	24	(1)
Berries other than strawberries	69	132	52
Cabbage	207	164	125
Carrots	226	106	57
Cauliflower	30	116	72
Celery	2, 965	72	20
Cucumbers	640	308	295
Lettuce	544	257	244
Melons, including watermelons	188	160	74
Onions	374	50	[2] 364
Peas, green	494	70	739
Potatoes, Irish, home use or for sale	156	32	[3] 5
Spinach	1, 387	300	111
Squash	20	13	90
Sweet corn	392	167	209
Strawberries	607	1, 140	266
Tomatoes	2, 621	4, 805	8, 207
Orchard fruits and nuts:	*Number*	*Number*	*Number*
Apple trees	14, 372	3, 782	1, 909
Apricot do	41, 354	17, 429	8, 454
Almond do	195, 699	116, 164	92, 690
Cherry do	53, 936	23, 930	13, 576
Citrus do	102, 401	36, 137	16, 672
Fig do	16, 583	6, 479	4, 241
Grapevines	9, 250, 363	5, 074, 303	2, 792, 160
Olive do	159, 882	76, 355	79, 994
Peach do	[4] 345, 881	[4] 80, 030	26, 659
Pear do	728, 259	346, 975	445, 146
Persimmon do	859	1, 822	(1)
Plum and prune do	527, 767	190, 696	89, 747
Pomegranate do	437	258	(1)
Quince do	5, 380	6, 317	(1)
Walnut do	19, 126	26, 644	30, 467

[1] Not reported.
[2] Dry onions only.
[3] Does not include acres with less than 10 bags harvested.
[4] Includes nectarines.

ALFALFA

Alfalfa is grown chiefly on bottom lands along the Sacramento, American, and Cosumnes Rivers on soils of the Columbia, Sacramento, and Hanford series, and occasionally on the deep phases of San Joaquin soils. The principal variety is Chilean. Commercial stands usually last 4 or 5 years and produce 5 or 6 cuttings a season. Most of the alfalfa grown on the San Joaquin soils and part of that grown along the Sacramento River is pastured or fed directly to dairy cattle. Much of that grown in the American Basin just north of Sacramento is baled and sold for hay, both locally and on the general market. An alfalfa meal plant near Walnut Grove takes most of the alfalfa grown in that neighborhood. The meal is used almost solely for mixed poultry feeds. No serious diseases or pests affect alfalfa in this area. When alfalfa caterpillars are numerous, they are controlled by clipping the stand and flooding. Little commercial fertilizer is used on alfalfa, except for occasional applications of superphosphate.

APRICOTS

Most of the apricot orchards in this area are small ones in the northeastern part of the county, mainly on soils of the Whitney series. The principal varieties are Blenheim and Royal. Yields are not high. Brown rot, the most common disease, is controlled by sprays of calcium arsenate or bordeaux mixture. Little fertilizer is used. Fertilizers furnishing 70 to 100 pounds of nitrogen an acre are the most effective for apricots in this area.

ASPARAGUS

Asparagus is grown on the river-bottom soils of the Sacramento River and the lower part of the American River, chiefly on soils of the Columbia, Sacramento, Burns, and closely related series. Little commercial fertilizer is used. Wireworms, the worst pest, can be partially controlled by flooding the land. Even this does not prevent considerable damage, and wireworms often completely ruin a stand. Asparagus is cut from February to May. The early part of the crop is sold mostly for fresh market use, but at the peak season in March and April much of it is canned.

BEANS

Beans, chiefly Pink and Cranberry varieties, are grown mostly along the Sacramento River on soils of the Columbia, Sacramento, and related series. The yields on Columbia soils are particularly good. Little commercial fertilizer is used. The major pests and diseases affecting beans are root rot, wireworm, and red spider. Sulfur dusting by airplane is occasionally attempted to control red spider, but the main control for all three problems is crop rotation.

CHERRIES

Cherries are grown mainly along the banks of the Sacramento River on Columbia or Sacramento soils and on the Chualar soils along Linda Creek, but some cherry trees are also grown on the Whitney and a few other soils. Yields are fairly high, particularly along the Sacramento River. The main variety is Royal Ann; other varieties are Bing and Black Tartarian. Brown rot affects

cherries and is controlled mainly by spraying with bordeaux mixture. Some fertilizer, mainly nitrogen-bearing kinds, is used on cherries. The rate is 70 to 100 pounds of nitrogen an acre. Even larger quantities are applied to some of the older orchards.

CITRUS FRUITS

Citrus plantings in the county are confined to the district around Fair Oaks. Navel orange groves predominate but there are a few acres of grapefruit. The plantings are small, and yields are not high. Commercial fertilizers are not used extensively, but green manure crops, mostly mustard, are used almost universally. The winter weather is not so warm as it should be for citrus fruit, and frost materially reduces the yield. Orchard heaters are not used extensively in the citrus groves of this area.

GRAIN SORGHUM

Grain sorghum is grown extensively on bottom lands along the Sacramento River and in places on the bottoms along the Cosumnes and American Rivers. It is a rotation crop, and the grain is used mostly in mixed feeds, especially for poultry. The crop is seldom fertilized. Its main disease is smut, for which there is no definite control except crop rotation.

GRAPES

Of the grapes grown in the area, by far the most important variety is the Tokay. Thompson Seedless and Mission grapes are grown in smaller plantings. The Tokay are grown principally on soils of the San Joaquin series, mainly in the district between the American and Cosumnes Rivers. The early grapes are shipped to market for table use, and later grapes are sold to wineries. The Mission grapes are used almost entirely for wine. They are grown in the Fair Oaks-Folsom area, mostly on the Whitney soils but to some extent on the Redding, Corning, San Joaquin, and Alamo soils.

Yields of grapes vary, mainly according to soil conditions. Tokay grapes on the Honcut soils have yielded as high as 15 tons per acre, whereas they seldom yield 5 tons on the San Joaquin soils. Yields of 4 or 5 tons an acre are considered fairly good on most of the soils. The wine grapes are usually not as well cared for as the table grapes and give lower yields.

Some commercial fertilizer is used on the table grapes, but experiments conducted through the Farm Advisor's office indicate that very little benefit is derived from fertilizing. The principal diseases of grapes are phylloxera and mildew. Phylloxera can be partly controlled by use of resistant root stock; and mildew is controlled by dusting with sulfur.

HOPS

In this area hops are grown only on the Columbia and Hanford soils, chiefly on the bottom lands along the American and Cosumnes Rivers. The crop is normally heavily fertilized with manure, green manure, and commercial fertilizer. Where satisfactory manure or green-manure fertilizers are available, the common commercial fertilizer is 0–10–10 or 0–12–12; but where the organic materials are not sufficient the common mixes are 10–10–5 and 6–12–8. Fertilizer

is applied as a side dressing at the rate of 600 to 800 pounds an acre early in spring. The use of fertilizer often increases the yield as much as 2 to 3 bales an acre. The common diseases and pests of hops are mildew, which is controlled by dusting with copper compounds, and red spider, which is controlled by treatment with sulfur and dinitro compounds.

Labor costs are high for the handling and harvesting of hops. Yields of 8 to 10 bales an acre, each bale containing approximately 200 pounds of cured hops, are considered good.

OLIVES

Olives grow on a variety of soils, but the largest acreages are on soils of the Whitney series in the Fair Oaks-Folsom district. Some orchards are in the eastern part of the Sacramento Valley, mostly on San Joaquin and Redding soils, but many of these have been abandoned. The trees, which are in small scattered plantings, are not fertilized. The principal disease, olive knot, is controlled by surgery. Olives for canning and oil are sold to two processing plants in the vicinity of Sacramento.

PEACHES

The peach orchards are not large and are located mostly on Columbia and Hanford soils along the Sacramento and American Rivers and fairly close to the city of Sacramento. About three-fourths of the trees are clingstone varieties grown exclusively for canning, and one-fourth are freestone peaches, usually marketed fresh. Peach blight, the principal disease, is controlled by spraying with bordeaux mixture in fall. Some nitrogenous fertilizers are used successfully on peaches, but as a rule no fertilizer is used.

PEAS

Peas are grown mostly on the bottom land along the Sacramento River, and are sold fresh. Peas are grown in winter, usually without irrigation, and receive little commercial fertilizer. Aphids, for which there is little or no control, are the principal pest. Mildew often causes considerable damage during the prolonged periods of rainy or cloudy weather. Peas are often followed by a late crop, such as tomatoes.

PEARS

Pears are grown in this area chiefly along the banks of the Sacramento River. The orchards, seldom more than a quarter of a mile from the stream, are mostly on Columbia and Sacramento soils. The trees are planted close together and yields are heavy. Bartlett pears are in the majority. A small acreage is in Winter Nelis and Hardy, which are grown mostly on the Whitney, Siskiyou, and Holland soils in the vicinity of Folsom. Yields here are much less than for the Bartletts along the Sacramento River. The main diseases and pests are pear blight, controlled by surgery; codling moth, controlled by frequent applications of lead arsenate sprays; and San Jose scale, controlled successfully by dormant oil sprays. Nitrogenous fertilizers are used to some extent on Bartlett pears with favorable results, especially on old trees.

PLUMS AND PRUNES

Plums and prunes are grown on a relatively large acreage in this area. Most of the plum orchards are in the Folsom-Fair Oaks district and in the vicinity of Mills and Perkins. Some of the most common varieties grown are: President, Duarte, Beauty, Tragedy, Wickson, Santa Rosa, and Formosa. The fruit is marketed fresh. Prunes are grown chiefly along the river bottoms of the Cosumnes River, particularly near Slough House, on the Hanford soils. Yields are fair to good, but the source of irrigation water is not dependable in this district. Both plums and prunes are affected by brown rot, red spider, and aphids. The brown rot is controlled by sprays of calcium arsenate or bordeaux mixture; red spider by sulfur dust; and aphids by commercial sprays. Little fertilizer is used on plums or prunes.

RICE

Rice is grown in the American Basin on soils of the Alamo, Freeport, and Sacramento series. This is the only part of the area suitable for rice. The nights are too cool for it to mature properly elsewhere along the Sacramento River. Water requirements are high—7 or 8 acre-feet of water each season. Little commercial fertilizer is used. No specific diseases or pests need control.

SMALL GRAINS

Large acreages of wheat, oats, and barley are grown in this area. Most of the wheat, principally Baart and White Federation varieties, is planted on soils of the San Joaquin, Redding, Alamo, and Whitney series and is dry-farmed. Because summer fallowing is necessary for successful dry-farming in this area, nearly all the grain is sown in fall. Yields are fairly low, from 8 to 20 bushels an acre. Wheat is susceptible to smut, for which the seed is treated with copper carbonate.

Oats are grown mainly as a fill-in crop. They often are planted with vetch and either cut for hay or used as a green-manure crop. Acreages are generally large, but extremely variable from year to year. Most oats and oat-legume crops are grown under irrigation, mainly near the Sacramento River on soils of the Sacramento and related series.

Barley is grown widely. On the river-bottom soils, irrigation is not needed during most seasons. On the Redding, Corning, Alamo, Whitney, and San Joaquin soils, barley is dry-farmed in about the same way as wheat, but yields are somewhat higher. Along the river bottoms, barley is used mainly in rotation or as a fill-in crop during the early part of the season and is followed by a crop such as beans or late tomatoes. Barley stripe, the principal disease, can be controlled fairly successfully by treating the seed with copper carbonate. No commercial fertilizer is used on barley or any of these small-grain crops.

STRAWBERRIES

Strawberries are grown almost exclusively on San Joaquin soils near Florin and Elk Grove. The plants are set out in raised beds, with either 2 or 4 rows to the bed. Stands last 4 or 5 years and produce most heavily during the second and third years. The strawberries are nearly all fertilized annually with 600 to 1,000 pounds of complete fertilizer an acre. The percentage of nitrogen in the fertilizer is

usually increased as the plants get older. Fertilizer mixtures frequently used at the time of survey were 4–10–10, 6–12–8, or 8–6–8. The common pest of strawberries in this area is crown borer, which is controlled by roguing and rotation. Several seasons must elapse, however, before a field can be replanted successfully to strawberries.

SUGAR BEETS

Sugar beets are grown on soils of the Sacramento, Columbia, Hanford, and related series. Yields are fairly high. Most plantings receive either green manure or commercial fertilizer. The type of commercial fertilizer preferred for sugar beets is high in nitrogen, or in nitrogen and phosphorus, and contains little if any potash. Fertilizers commonly used are urea, ammonium phosphate, 10–10–5, or liquid ammonia. The usual applications are about 200 pounds an acre of urea or ammonium phosphate or 300 pounds of 10–10–5. Applications of liquid ammonia usually supply 70 to 100 pounds of nitrogen per acre. No beet-sugar factories are located within the area, and most of the beets grown are sent to Clarksburg (in Solano County), about 18 miles south of Sacramento, or to Knights Landing (in Yolo County), about 25 miles northwest of Sacramento. The principal diseases of sugar beets are root rot, which is controlled by rotation; and curlytop, which is controlled partly by rotation but more effectively by the use of resistant varieties.

TOMATOES

Tomatoes are grown on the Columbia, Burns, and Sacramento soils. They yield as much as 30 tons an acre under favorable conditions. Yields on the San Joaquin soils are much less, seldom averaging above 10 tons an acre. More than 90 percent of the tomatoes grown in the area are canned. Little fertilizer is used in the production of canning tomatoes. The principal diseases are fusarium wilt and verticillium wilt, which are controlled by rotation. Tomatoes are not planted more than 2 years in succession on the same field.

TRUCK CROPS

Truck crops in wide variety are grown in the Sacramento Area, mostly along the river bottoms of the Sacramento River and the lower part of the American River. Considerable acreages are also grown on the San Joaquin and Perkins soils south and southeast of the city of Sacramento. Crops grown primarily for marketing fresh are usually fertilized heavily, whereas those grown mainly for canning are not so heavily fertilized. Most of the insect pests and diseases of root crops are controlled by crop rotation; pests of leafy crops are controlled by sprays.

LIVESTOCK

Livestock in this area can be divided into grazing stock and stock that is intensively fed. The first group consists of beef cattle and sheep that graze on the alluvial plains or in the foothills of the eastern part of the area. Cattle can graze in this area throughout the year, although most herds are pastured in the higher mountains from June to late October. Some supplemental feeding is usually necessary late in summer or early in fall, and feeding lots or irrigated pastures are generally used in finishing beef cattle for market. Some sheep are

also raised on irrigated pastures, and they commonly are pastured on grain-stubble and other fields after harvesting.

The second group consists mainly of dairy cattle and poultry. Dairy cattle are usually kept on irrigated pastures, and much of the milk goes to Sacramento for distribution or processing. Much of the poultry is raised on small farms near Sacramento as a part-time enterprise. Hogs are generally raised where garbage and spoiled or damaged crops are available.

Table 3 gives the number of specified livestock in Sacramento County in 1930, 1940, and 1950.

TABLE 3.—*Number of livestock on farms in Sacramento County, Calif., in stated years*[1]

Livestock	1930	1940	1950
	Number	*Number*	*Number*
Horses	5, 769	[2] 3, 109	2, 297
Mules	788	[2] 231	77
Cattle	29, 878	[2] 27, 598	54, 662
Milk cows	10, 860	13, 884	18, 145
Sheep and lambs	60, 347	[3] 17, 314	32, 552
Swine	9, 996	[4] 8, 281	10, 820
Chickens	[2] 595, 581	[4] 497, 072	[4] 573, 172
Other poultry	71, 293	[4] 13, 612	[5] 17, 465
Goats and kids	498	[4] 372	790

[1] All ages on April 1, except as noted.
[2] Over 3 months old on April 1.
[3] Over 6 months old on April 1.
[4] Over 4 months old on April 1.
[5] Turkeys only, 4 months old and over.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field. The soil scientist walks over the area at intervals not more than one quarter of a mile apart and bores into the soil with an auger or digs holes with a spade. Each such boring or hole shows the soil to consist of several distinctly different layers, called horizons, which collectively are known as the soil profile. Each of these layers is studied carefully for its characteristics that affect plant growth.

The color of each layer is noted. The darkness of the surface layer is usually related to its content of organic matter; streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration. Texture, or the content of sand, silt, and clay in each layer, is determined by the way the soil feels when rubbed between the fingers and is later checked by mechanical analysis in the laboratory. Texture affects the quantity of moisture, plant nutrients, and fertilizer held available to plants, and difficulty of cultivation. Structure, or the way the soil granulates and the number of pores or open spaces between particles, indicates how easily water and plant roots can penetrate the soil. Consistence, or the tendency of the soil to crumble or to stick together, indicates whether the soil will stay open and porous under cultivation. The underlying rocks and the resulting parent material from which the soil has been developed

affect the quantity and kind of plant nutrients the soil may contain. Simple chemical tests show how acid or alkaline the soil may be.[3] The depth to bedrock or to compact layers is determined. The quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost by erosion, and other external features are observed.

On the basis of all these characteristics, soil areas much alike in the kind, thickness, and arrangement of their layers are mapped as one soil type. If other characteristics significant to agriculture vary a great deal, the soil type may be separated into two or more phases.

All the soil types that have about the same kind, thickness, and arrangement of layers, except for texture of the surface layer, are included in the same soil series. The name of a place near where a soil series was first found is chosen as the name of the series. Thus, Hanford, Whitney, and Honcut are names of important series in the Sacramento Area. Three types of the Hanford series are found—Hanford sand, Hanford loamy fine sand, and Hanford very fine sandy loam. These differ in the texture of the surface soil, as their names show. Hanford loamy fine sand is divided into three phases: Hanford loamy fine sand, nearly level; Hanford loamy fine sand, overflowed, nearly level; and Hanford loamy fine sand, channeled, nearly level.

When very small areas of two or more kinds of soil are so intricately mixed that they cannot be shown separately on a map of the scale used, they are mapped together, and the areas of the mixture are called a soil complex. Siskiyou-Holland sandy loams, rolling and hilly, is a complex of Siskiyou sandy loam, rolling and hilly, and Holland sandy loam, rolling and hilly, in the Sacramento Area.

Areas such as steep terrace escarpments, areas affected by mining operations, and dry stream beds that have little true soil are not designated with series and type names but are given descriptive names and called miscellaneous land types. Terrace breaks, Slickens, Tailings, and Riverwash are miscellaneous land types in the Sacramento Area.

The soil type or, where the soil type is subdivided, the soil phase is the unit of mapping in soil surveys. It is the unit or the kind of soil that is most nearly uniform and has the narrowest range of characteristics. For this reason land use and soil management practices can be more definitely specified for it than for broader groups of soils that contain more variation. One can say, for example, that soils of the Whitney series are used largely for production of small grain, orchard fruits, and berries. More detailed statements can be made for types and phases: for example, that Whitney fine sandy loam, steep, is used entirely for grazing because of its steep (25+ percent) slopes; that Whitney fine sandy loam, deep, undulating and rolling, is a little better suited to orchard trees than comparable Whitney soils because of its deeper profile; or that Whitney fine sandy loam, rolling and hilly, is more susceptible to erosion under clean cultivation than are the phases on lesser slopes. All of these phases are included in the Whitney series.

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[3] The reaction of the soil is its acidity or alkalinity, expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity, and lower values, acidity.

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SOILS

The soils of the Sacramento Area are extremely variable. They range from strongly acid to calcareous, and from very low in organic matter to highly organic. Some are deep recent alluvial soils; others are shallow residual soils of the uplands. All occur within an area having fairly uniform climatic conditions, and the differences among the soils are mainly caused by differences in parent materials, drainage, and topography. Most of the alluvial soils are of mixed mineralogical origin, and some have not been in place long enough to develop distinct profiles, whereas others have strongly developed profiles. The soils occur at elevations ranging from 5 feet below to 800 feet above sea level.

SOIL SERIES AND THEIR RELATIONS

The soil series of this area are placed in four groups according to distinct physiographic divisions: (1) Soils of the uplands developed on consolidated bedrock; (2) soils developed on flood plains and recent alluvial fans; (3) soils developed on old alluvial plains and terraces; and (4) soils developed in alluvial basins. An additional group consists of miscellaneous land types. Following is a discussion of the soil series by physiographic groups.

SOILS OF THE UPLANDS DEVELOPED ON CONSOLIDATED BEDROCK

The soils of the Auburn, Holland, Siskiyou, Whiterock, Dorado, Amador, Whitney, Pentz, Peters, and Ayar series are in this group. In general, they are used for pasture, but most of the Whitney soils are cropped. Dry-farmed grain and a wide variety of fruit and nut crops, including practically all of the citrus fruits of the area, are grown on Whitney soils. Grain fields are extensive, but most fruit orchards and vineyards are small plantings ranging from less than 1 acre to 10 or 15 acres. Most of the fruit grown on these soils is for home use. The operators have outside sources of income, usually employment in Sacramento or in the railroad yards or shops in Roseville (in Placer County).

The small farms on the Whitney soils produce mainly for home use. The owners usually have a few chickens, a cow or two, and several kinds of fruit trees. The trees are seldom properly pruned, irrigated, or sprayed, hence yields are not high and the fruit is often of inferior quality. Some fruit is also grown on small acreages of Holland and Auburn soils near Folsom. Some vegetables and field crops are also grown on these soils at the State Prison Farm near Folsom.

SOILS DEVELOPED ON FLOOD PLAINS AND RECENT ALLUVIAL FANS

In this group are soils of the Hanford, Chualar, Honcut, Rydberg, Columbia, Bear Creek, and Oakley series. These soils are ordinarily suitable for intensive agriculture and are used for a wide variety of truck, field, and fruit crops. The crops are generally of good quality, and yields are high. Hops are grown only on these soils, and yields are satisfactory. Many of the soils are still subject to overflow. Many areas flooded for a short time in winter are located along the Cosumnes River and farmed to alfalfa, grain sorghum, hops, and some fruit, mostly prunes. Some lower areas along this river could be farmed if protected from flooding, but they are now used only for pasture, during the dry season.

SOILS DEVELOPED ON OLD ALLUVIAL PLAINS AND TERRACES

The soils of this group are the Corning, Redding, Perkins, San Joaquin, Alamo, and Glann. They have moderately or strongly developed profiles and are located on areas of old valley-fill material that occupy valley plains and terraces. Most of the soils are used for dry-farmed grain or range pasture. Grain yields are variable and dependent upon the season. Summer fallowing is generally practiced. Wheat is grown more widely than barley on these soils. Wheat yields from less than 8 to as much as 20 bushels an acre, and barley slightly more. The pasture is of fair to good quality.

Soils of the San Joaquin series, the most extensive of this group and long considered suitable only as grain and pasture land, grow a fairly wide variety of shallow-rooted crops under irrigation. Practically all of the strawberries grown in this area are on these soils. Yields are moderate. Good fields yield 5,000 to 6,000 quarts an acre. Grapes, mostly of the Tokay variety, are also grown on these soils, but yields are inferior to those on the Honcut and Hanford soils of the Lodi district immediately to the south. Some truck crops, such as lettuce, celery, carrots, leeks, radishes, and cauliflower, are grown in the vicinity of Perkins and Florin. Yields are fair to moderate.

The San Joaquin soils are not so productive as the more recently developed alluvial soils. Nevertheless, they produce strawberries and Ladino clover as well as most other soils and probably should be used more commonly for these crops. A good stand of Ladino clover, properly managed, will support 10 or more head of sheep per acre for a 9-month period each year. Water for irrigation is a big problem, but the water table appears to be staying at a fairly constant level at the present rate of pumping. Other irrigated crops such as fruit, grapes, alfalfa, and field crops usually produce less than half as much an acre as they do on the recent alluvial soils. Ladino clover does very well on the Glann soil, but only fair on the Alamo.

SOILS DEVELOPED IN ALLUVIAL BASINS

Soils of the Sacramento, Freeport, and Burns series are in this group. These soils occupy low areas that under natural conditions were subject to overflow by the major streams. For the most part the soils are dark colored, contain moderately high to high quantities of organic matter, and do not have well developed profiles. Areas now being farmed are protected by levees, and the water table is controlled by drainage ditches. These soils are used mostly for irrigated field and truck crops. Some pears and cherries are grown on the banks of the Sacramento River on the better drained natural levees, an eighth to a quarter of a mile wide, which are the only areas of these soils suitable for fruit trees.

Large acreages of alfalfa, sugar beets, beans, and barley are grown, as well as a wide variety of truck crops. Asparagus and tomatoes are the most extensive truck crops. Rice is an important field crop. Farms are usually large.

MISCELLANEOUS LAND TYPES

Land types are mapped in places where practically no soil exists. Generally, such land types represent nonarable areas: Placer diggings, Riverwash, Scabland, Tailings, and Terrace breaks. In addition, the group includes Kitchen middens and Slickens, which have some agricultural value.

SOIL DESCRIPTIONS

In the following pages, the soil types, phases, and land types are described in detail, and their agricultural relations are discussed. Their location and distribution are shown on the map, and their approximate acreage and proportionate extent are given in table 4.

ALAMO SERIES

The dark-gray clay soil of the Alamo series has developed from valley-fill materials that rest at shallow depths on old cemented hardpan substrata. The series is associated with the San Joaquin soils. It has similar relief and similar parent material, but it occurs in more poorly drained areas where the finer materials are washed in from surrounding slightly higher ground.

Alamo clay (adobe), nearly level (0–1 percent slopes) (Aa).—This soil occurs in small bodies scattered over the valley plain and in larger areas along the lower edge of the valley plain near the valley trough.

The surface soil, extending to depths of 6 to 15 inches, is dark-gray adobe clay. It swells and becomes only slightly permeable to water when wet, but shrinks and cracks deeply when dry. Small secondary cracks give it a somewhat flaky or coarse granular structure at the immediate surface. This layer contains many fine roots.

The upper subsoil extends to depths of 12 to 30 inches; it is a dark-gray compact clay. The large surface cracks extend a considerable distance down into this layer, but the secondary cracking that forms the small angular aggregates in the surface soil is absent. The material in this upper subsoil has a somewhat prismatic or blocky structure, and slightly darker colored colloidal stains glaze the surfaces of the aggregates. The interior of the aggregates is somewhat mottled with rust-brown iron stains. Some buckshotlike pellets are found, but are not so numerous here as in the layer below. Some fine roots occur throughout this layer but fewer than in the surface soil. The reaction is about neutral.

The lower subsoil, extending to depths of 20 to 60 inches, is grayish-brown or gray compact clay. When dry it forms somewhat cubical hard aggregates coated with colloidal stains. Considerable rust-brown or gray iron mottling and many buckshotlike pellets occur throughout this material. Segregated lime occurs in seams in this layer, and in some places there are dark shiny manganese stains and a few fine roots.

The cemented substratum occurs at extremely variable depths ranging from 20 to 60 inches. This material, like that underlying the San Joaquin soils, is semiconsolidated and stratified. The upper part is platy. Some manganese stains occur along seams and cracks, and usually some segregated lime. The material is crumbly where lime is present in large quantities.

This soil is used mostly for grain or grain hay and pasture. Grain yields are relatively poor, or somewhat less than on the San Joaquin soils except in fairly dry seasons. During wet seasons the water stands so long on the soil that it either drowns the grain or greatly retards its growth in the early part of the season. Pasture is fairly good. The soil is favorable for burclover, and some Ladino clover is grown under irrigation. In the American Basin this soil is generally deeper to the substratum, and here is is used mostly for rice grown in rotation with grain or grain sorghum. Rice yields are fair but not so good as on the Freeport and Sacramento soils in the same locality.

TABLE 4.—*Approximate acreage and proportionate extent of the soils mapped in the Sacramento Area, Calif.*

Soil	Acres	Percent
Alamo clay (adobe), nearly level	35,842	6.4
Amador fine sandy loam:		
Rolling and hilly	9,063	1.6
Steep	683	.1
Undulating	1,947	.3
Auburn stony loam:		
Rolling and hilly	6,676	1.2
Steep	2,751	.5
Undulating	485	.1
Ayar clay loam, rolling and hilly	160	(1)
Bear Creek gravelly loam, very gently sloping	7,995	1.4
Burns silty clay loam, nearly level	3,680	.7
Chualar gritty clay loam, nearly level	400	.1
Chualar gritty loam:		
Channeled, very gently sloping	460	.1
Very gently sloping	311	.1
Columbia fine sandy loam:		
Channeled, nearly level	370	.1
Nearly level	4,244	.8
Overflowed, nearly level	203	(1)
Columbia fine sandy loam (over Freeport clay), nearly level	115	(1)
Columbia fine sandy loam (over Sacramento silty clay loam), nearly level	395	.1
Columbia loamy fine sand:		
Channeled, nearly level	436	.1
Nearly level	794	.1
Overflowed, nearly level	51	(1)
Columbia loamy fine sand (over Freeport clay), nearly level	262	(1)
Columbia silt loam:		
Nearly level	3,459	.6
Overflowed, nearly level	2,327	.4
Columbia silt loam (over Freeport clay), nearly level	161	(1)
Columbia silt loam (over Sacramento silty clay loam), nearly level	6,378	1.1
Columbia silty clay (over Freeport clay), nearly level	699	.1
Columbia silty clay (over Sacramento silty clay):		
Nearly level	12,671	2.3
Overflowed, nearly level	6,424	1.1
Corning gravelly loam, undulating	8,824	1.6
Dorado stony silt loam:		
Rolling and hilly	5,617	1.0
Steep	1,156	.2
Freeport clay (adobe), nearly level	7,887	1.4
Glann loam, nearly level	7,693	1.4
Gravel pits	128	(1)
Hanford loamy fine sand:		
Channeled, nearly level	2,421	.4
Nearly level	2,892	.5
Overflowed, nearly level	3,646	.7
Hanford sand, overflowed, nearly level	72	(1)
Hanford very fine sandy loam:		
Channeled, nearly level	629	.1
Nearly level	3,691	.7
Overflowed, nearly level	6,056	1.1
Holland sandy loam, rolling and hilly	960	.2
Honcut gravelly loam, nearly level	889	.2
Honcut loam:		
Channeled, nearly level	142	(1)
Nearly level	3,171	.6
Overflowed, nearly level	1,172	.2

[1] Less than 0.1 percent.

TABLE 4.—*Approximate acreage and proportionate extent of the soils mapped in the Sacramento Area, Calif.*—Continued

Soil	Acres	Percent
Honcut loam (over San Joaquin hardpan substratum), nearly level	545	0.1
Honcut very fine sandy loam:		
Nearly level	1,488	.3
Overflowed, nearly level	1,782	.3
Honcut very fine sandy loam (over Bear Creek gravelly loam), overflowed, very gently sloping	2,168	.4
Kitchen middens	171	(1)
Oakley loamy fine sand (over Glann loam), undulating	882	.2
Oakley sand, undulating	108	(1)
Pentz loam:		
Rolling and hilly	2,108	.4
Steep	947	.2
Pentz-Redding gravelly loams:		
Rolling and hilly	17,099	3.0
Steep	5,368	1.0
Undulating	1,836	.3
Pentz sandy loam:		
Rolling and hilly	2,236	.4
Steep	1,618	.3
Perkins gravelly loam, very gently undulating	6,834	1.2
Peters clay (adobe), rolling and hilly	2,839	.5
Placer diggings	4,025	.7
Redding cobbly loam, undulating	106	(1)
Redding gravelly loam, undulating and rolling	65,905	11.7
Riverwash	1,883	.3
Rydberg loam, very gently sloping	248	(1)
Sacramento silty clay loam:		
Nearly level	17,158	3.0
Overflowed, nearly level	354	.1
San Joaquin loam-Alamo clay (adobe), very gently undulating	6,879	1.2
San Joaquin loam:		
Deep, undulating	4,833	.9
Undulating	35,510	6.3
Very gently undulating	90,490	16.1
San Joaquin sandy loam:		
Deep, undulating	10,825	1.9
Undulating	32,860	5.8
Very gently undulating	4,909	.9
Scabland	1,505	.3
Siskiyou-Holland sandy loams:		
Rolling and hilly	1,420	.3
Stony and steep	513	.1
Slickens	707	.1
Tailings	16,404	2.9
Terrace breaks, Redding-Corning soil materials, steep	1,705	.3
Whiterock stony loam:		
Rolling and hilly	8,379	1.5
Steep	1,816	.3
Whitney fine sandy loam:		
Deep, undulating and rolling	7,246	1.3
Rolling and hilly	25,854	4.6
Steep	152	(1)
Undulating	6,243	1.1
Whitney gravelly sandy loam, rolling	114	(1)
Total	562,560	100.0

[1] Less than 0.1 percent.

AMADOR SERIES

The soils of the Amador series have developed from the softer clayey and sandy material of the Valley Springs formation, and to a small extent on the Ione formation. They usually occur on gently rolling to hilly areas, are normally shallow with little profile development, and are strongly acid. The more nearly level areas have many small mounds that generally rise 8 to 12 inches higher than the surrounding depressions. The soil on the mounds is usually 12 to 18 inches deep, whereas that in the depressions is only 4 to 10 inches.

Although extremely variable in color, these soils are for the most part light brownish gray, pale brown, or very pale brown. They are light brown and pinkish gray in places. There is no distinct subsoil. Yellowish slaglike outcroppings, harder than the usual parent materials, occur in some localities. These are apparently iron deposits. The parent materials are usually soft, very light colored, sandy or clayey stratified formations. Some brush and tree roots penetrate the sandier materials, but seldom the clay. The clay of the Ione formation is highly kaolinitic, in places almost white, and is mined for ceramics.

The Amador soils are closely associated with the Pentz and Peters soils. In many places they are associated with soils of the Redding series, which cap the formations giving rise to the Amador, Peters, and Pentz soils. In these places rounded hard gravel from Redding soil materials may be scattered over the surface of the soils occupying the slopes below. The Amador soils may derive their reddish or pinkish cast from this material, although in some localities the clayey or sandy parent materials are reddish.

Amador soils support a poor cover of grasses and associated plants and a scattered growth of the scrub oak and digger pine, or of manzanita brush. Pasture is meager. Alfileria, red brome, and ripgut are the most common forage plants. None of these soils are under cultivation.

Amador fine sandy loam, rolling and hilly (8–25 percent slopes) (Ab).—The 4- to 16-inch layer of this soil is predominantly very pale brown or light brownish-gray, but may be reddish or pinkish. Its texture varies. A few areas are coarser or finer than the typical fine sandy loam. The finer textured areas are silty and not very sticky; their clay is probably kaolinitic. There is no definite structure. Many fine pores appear; some are tubular root holes and others are vesicular. The surface inch is slightly darker than the rest of this layer and is medium acid (pH 6.0). The rest is very strongly to medium acid, (pH 4.5 to 6.0).[4] An accumulation of fine grass roots is found near the surfaces, but only the larger brush or tree roots extend through the profile.

The subsoil is not very different from the surface soil in color, texture, structure, and reaction, especially in very shallow profiles. In the few areas where soil depth exceeds 20 inches, there is a thin finer textured layer in the subsoil. This layer is usually relatively massive loam or clay loam. The lower part of the soil has few roots,

[4] Soil reactions given in these descriptions were determined in the field by simple colorimetric methods. Although these tests give approximately correct results and are useful for rapid field examinations, they are not suitable for as accurate interpretation as the more precise laboratory methods.

but many vesicular pores. The reaction is usually strongly to very strongly acid (pH 4.5 to 5.5), but occasionally extremely acid (pH 4.0). The soil grades into very light colored, moderately soft sandstone or clayey bedrock. The clayey material is crumbly, not sticky, and probably highly kaolinitic. In places it is used for ceramics.

Some well-rounded hard gravel may occur. Gravel, however, is foreign to the formation giving rise to this soil, and in some places its presence probably results from mixture of gravelly materials with the finer sediments when the soil materials were deposited. In other places this gravel is a remnant of Redding soil material.

The natural vegetation consists of scrub oak, digger pine, and an undercover of sparse grasses. Some open grassy spots and some areas of brush, mostly manzanita with a little chamise, are found. This soil is used only for range pasture, but forage is scanty and of poor quality. The sparse vegetation offers little protection against erosion, which is increased by overgrazing. Erosion is now moderate and confined mostly to a few small steep-sided gullies.

Amador fine sandy loam, steep (25+ percent slopes) (Ac).—This soil has a variable profile ranging from very shallow to shallow. The surface soil is light brownish-gray, very pale-brown, or pinkish-gray fine sandy loam that includes some loam areas. The subsoil is of similar texture but of lighter color than the surface soil. It rests on parent bedrock of the Ione or related geologic formations at depths of 6 to 24 inches.

This soil is normally covered by manzanita or chamise brush or by scrub oak and digger pine. Some grass grows under the oak and digger pine but very little under the brush. The soil is used only for pasturing cattle and provides extremely meager forage. Because forage plants are such a small part of the cover, overgrazing seems to have had little effect on erosion. Erosion is severe on burned-over areas and moderate to slight where the vegetation has not been destroyed.

Amador fine sandy loam, undulating (3–8-percent slopes) (Ad).—This soil is less eroded than the more sloping Amador soils. The hummocky microrelief is characterized by many small mounds and by depressions locally known as hogwallows.

The surface soil is dominantly a very pale-brown or light brownish-gray fine sandy loam with many fine pores. The underlying subsoil is of the same or slightly finer texture and slightly more porous. The color varies, some areas having a pale yellow, pale reddish, pinkish, or even purplish color. In some localities water-worn quartz gravel occurs on the surface. The depth to bedrock is usually less than 12 inches in the depressions and seldom more than 20 to 24 inches on the mounds. The bedrock is soft, light-colored, clayey or sandy material of the Ione or related formations.

The cover on this soil is mainly alfileria and annual grasses. The growth of grass is better on the mounds than in the depressions, although still meager in comparison with that on the Pentz or Peters soils. Sparse stands of red brome and ripgut grasses, and some soft chess furnish inferior forage. These grasses are used mostly for winter and early spring grazing for stock that is moved to the Sierras for summer and fall pasture. The scattered oak and digger pine offer some shade and shelter for stock in hot or stormy weather.

AUBURN SERIES

Soils of the Auburn series are formed in place from igneous and metamorphosed igneous rocks, principally andesites and amphibolite schists. The soils are stony and extremely variable in depth but show some evidence of profile development. They are normally shallow. Depths usually range from 10 and 24 inches but may extend to 36 inches. These soils somewhat resemble the Aiken soils and were called shallow phases of Aiken soils in the soil survey of the Placerville Area, which joins the eastern edge of this survey (*13*). They are associated with the Dorado and Whiterock soils and occur rather extensively north of the Cosumnes River in the eastern part of the Sacramento Area.[5] Many angular rock fragments are found throughout the soil mass, and outcrops occur frequently.

The vegetation consists of scrub oak and digger pine, brush, or grass. These soils are used almost entirely for range pasture for cattle. Carrying capacity is less than that for either the Pentz or Peters soils.

Auburn stony loam, rolling and hilly (8–25 percent slopes) (AE).—This soil occupies mostly rolling to hilly areas, but the slope may be steeper. The surface soil is yellowish-red to light reddish-brown stony loam of strongly to slightly acid reaction (pH 5.0 to 6.5). Its structure is indefinite. The topmost part is usually thin and platy; the rest of the surface layer contains many fine pores and numerous fine grass roots.

The subsoil, at depths ranging from 4 to 12 inches, is slightly finer textured than the surface soil and is of similar or slightly darker color. It contains more worm holes, usually more angular rock fragments, and fewer roots, although in areas covered by brush or trees there are many coarse roots. The pH value ranges from 5.0 to 6.5.

In the shallower profiles, the subsoil is underlain by a thin layer of shattered bedrock and some of the soil material is mixed with hard angular rock fragments. In profiles deeper than 20 or 24 inches, a layer of yellowish-red, grading with depth to reddish-brown, or brown, clay or clay loam occurs. This layer is moderately compact, contains few roots, and changes more gradually into the weathered bedrock. The deeper, hard, massive, unweathered bedrock consists of dense fine-grained igneous rock and amphibolite schist. The pH ranges from 5.0 to nearly neutral.

This soil has many stones and bedrock outcrops, and for the most part is used for grazing. There are a few orchards, but the trees are irregular in size and many have died. Some grain and truck crops are grown on this soil at the State prison farm at Folsom, but with poor results. Orchards and cultivated fields may erode if left bare during the rainy season, but not so severely as the Whitney, Siskiyou, and Holland soils in the same vicinity. Under natural conditions the soil is covered either with grass or with an open stand of scattered oak and digger pine trees and a grass undercover. The oaks are small but are larger than those on the Whiterock soils. The forage produced is fair. It is superior to that on the Amador, Whiterock, and Dorado soils; about equal to that on the Siskiyou and Holland soils; and inferior to that on the Whitney, Pentz, and Peters soils.

[5] In this survey, because of development in the science of soil classification and the much greater detail in mapping since the earlier surveys, several changes have been made in soil names. The more important of these are noted in the text.

Auburn stony loam, steep (25+ percent slopes) (AF).—This soil has more rock outcrops and is normally shallower than Auburn stony loam on gentler slopes. The surface soil is light reddish-brown or yellowish-red stony loam. The subsoil is of similar color but somewhat heavier (finer) textured, slightly more porous, and usually rests abruptly on fairly hard fine-textured igneous or metamorphosed igneous rock.

This stony loam is used almost solely as range pasture for cattle. The ground cover consists of brush, grass, and scrub oaks; its carrying capacity is low. Some scrub oak is cut for fuel.

Auburn stony loam, undulating (3–8 percent slopes) (AG).—This soil is deeper and has fewer rock outcrops than the steeper areas of Auburn stony loam. The surface soil, a reddish-brown or yellowish-red stony loam, extends to depths of 8 to 15 inches. The upper subsoil is of similar color, but more porous and slightly finer in texture. A lower subsoil of heavy clay loam or light clay occurs more frequently than in rolling or hilly areas of Auburn stony loam. This clay layer is reddish-brown or brown, somewhat compact, and underlain by a thicker zone of weathered bedrock. The soil is strongly to slightly acid; the pH is 5.0 to 6.5 in the surface soil and slightly higher in the subsoil.

This inextensive soil is used entirely for pasture, although it would be as suitable for dry-farmed grain or grain hay as any of the areas of Auburn stony loam with rolling relief that are used for that purpose. Pasture is fairly good.

AYAR SERIES

The Ayar series, inextensive in this area, is represented by only Ayar clay loam, rolling and hilly. The Ayar soil occurs on rolling and hilly relief along Carson Creek. It developed on calcareous soft shale. It is the only calcareous soil developed on bedrock in this area; the surrounding soils are acid. The Ayar soil has some profile development.

The soil is friable throughout and appears to erode more rapidly than other soils developed on bedrock materials.

Ayar clay loam, rolling and hilly (8–25 percent slopes) (AH).—The surface soil is 6 to 15 inches of brown to dark reddish-brown, calcareous, friable clay loam. Despite its moderately fine texture, it crumbles easily to a granular condition. The lime is mostly disseminated, but in places appears as a few thin streaks along root cavities.

The subsoil, extending to depths of 12 to 36 inches, is brown or reddish-brown, highly calcareous clay loam. The aggregates are somewhat coated with colloidal stains and are firmer than those of the surface soil. Lime occurs in soft nodules and thin seams. Roots are fewer in this layer than in the surface soil. The subsoil becomes slightly lighter colored with depth and grades into soft, crumbly, highly calcareous shale bedrock. The quantity of segregated lime in the bedrock decreases rapidly with depth, and the color becomes nearly white.

The natural cover is scattered oaks and a dense growth of grasses. The soil is used only for pasture, for which it is fairly well suited. The carrying capacity is probably about the same as for the Peters soil. The sheet and gully erosion, somewhat more pronounced than on the other residual soils of the area, is caused largely by overgrazing.

BEAR CREEK SERIES

The Bear Creek series—represented in this area by Bear Creek gravelly loam, very gently sloping—consists of mixed alluvium derived chiefly from Redding soils. The soil is slightly acid. It is usually gravelly and has slight profile development. Color varies considerably, and depth ranges from 2½ to 6 feet or more. Bear Creek soil usually rests on older, partially consolidated, unrelated materials.

Bear Creek gravelly loam, very gently sloping (0–3 percent slopes) (BA).—This soil occupies narrow flood plains and alluvial flats that are seldom more than 300 or 400 yards wide. Meandering waterways that drain Redding or gravelly Pentz soils cut drainage channels with vertical sides, seldom more than 3 to 4 feet deep. The total area is not great, but many small bodies extend along drainageways throughout the Redding soils.

The surface soil is dark grayish-brown or grayish-brown gravelly loam. It has many grass roots and is fairly friable when moist but tends to bake hard on drying. The gravel is well rounded and consists mostly of quartz, quartzite, or andesite pebbles washed from the Redding soils. The reaction is slightly acid to nearly neutral (pH 6.0 to 7.0+).

The subsoil, which occurs at depths of 6 to 15 inches, is grayish-brown or brown gravelly loam that contains fewer grass roots than the surface soil. It is also considerably more porous and has many worm and insect channels. The surfaces of some of the channels are glazed with colloidal stains. The subsoil is friable when moist but dries fairly hard. It may contain a small amount of accumulated clay, but not enough to retard root or water penetration. The quantity of gravel and the reaction are similar to those of the surface soil.

The parent material, beginning at depths of 20 to 36 inches, consists of stratified, grayish-brown, pale-brown, or brown gravelly layers of variable texture that contain a few grass roots or insect channels. At depths ranging from 30 inches to more than 6 feet this material normally rests on a somewhat consolidated formation similar to that underlying the Redding soils.

This soil is used almost entirely for pasture, though a few areas associated with the Redding soils are dry-farmed to grain. Both grain and pasture are better than on the Redding soils.

BURNS SERIES

The Burns series is transitional between mineral and organic soils. It is highly organic and has a low volume weight and high moisture-holding capacity. The mineral material is fine-textured and very smooth. Burns soil is formed at elevations near sea level in basin-like areas in the valley trough. These basins were originally marshy and probably rarely dried, even during the dry summer season. The soil is closely associated with related soils of the Sacramento series but has a greater quantity of organic matter.

The surface soil is dark grayish brown or dark gray, fine-textured, granular, and high in organic matter. Underlying layers are made up of organic material and fine sediments usually high in silt. The organic layers may be raw and fibrous, or they may be muck without recognizable plant remains. The stratified organic and mineral layers

are underlain by a substratum of mineral soil material, normally fine-textured, which occurs 2½ to 7 or 8 feet below the surface. The substratum is gray, mottled with bluish-gray stains, usually micaceous, and noncalcareous. The entire profile of this soil is slightly or medium acid.

Burns silty clay loam, nearly level (0–1 percent slopes) (Bb).—This soil occurs in low basins in the southwestern part of the area, usually at elevations near sea level or slightly below. It is surrounded by other basin soils, mostly of the Sacramento series. The surface soil extends to depths of 8 to 24 inches; it is dark grayish-brown or dark-gray granular silty clay loam high in organic matter and slightly to medium acid. It appears to be at a stage of development transitional from mineral soil to an organic soil. The volume weight is low, and the water-holding capacity is high. Because of high organic-matter content, the soil is seldom sticky. Some very dry clods will float in water, and the soil maintains a friable consistence and does not puddle even when worked under unfavorable moisture conditions.

The subsoil is a dark-brown or dark-gray organic material that may be amorphous or fibrous. It extends to depths of 3 to 7 or 8 feet and may be stratified with thin layers of fine-textured mineral soil. A thin layer of light brownish-gray or pale-yellow ash from fires that burned a former surface mat of organic matter commonly occurs in this material. The mineral substratum underlying this organic material consists of clay or silty clay, which is usually somewhat micaceous but seldom calcareous. This clay contains considerable blue-gray iron mottlings and is nearly always below the permanent water table.

Despite the nearly flat relief, some leveling must be done before the soil can be farmed to irrigated crops. It must also be properly drained and protected from overflow by levees. The pervious soil material is drained and subirrigated by controlling the height of the water in a system of ditches.

Where farmed, this soil is used mostly for asparagus, tomatoes and alfalfa. Asparagus and tomatoes produce very well. Alfalfa stands are short lived; yields are high the second and third years but drop off rapidly thereafter because of damage from the high water table during the winter months. Grain and some grain sorghum are also grown, but yields are low because of the very wet conditions during winter.

CHUALAR SERIES

The soils of the Chualar series occur on alluvium that is derived mainly from granitic rock but contains some intermixed materials from both basic igneous and sedimentary rocks. They occupy areas along Linda Creek. These soils are grayish brown or dark grayish brown. They have slightly compact subsoils which contain accumulations of clay. In this area, the Chualar soils are not quite so well-drained as in other areas and are subjected to a high water table during part of each year. The water table has permitted moderate accumulation of organic matter in the soils.

The underlying parent materials consist of stratified layers of variable stream deposits, all containing considerable grit. The color may be pale brown in coarse sandy strata, whereas the strata of gritty clay loam may be grayish brown and somewhat mottled with rust-brown iron stains.

Depth to the water table ranges from about 3 to 7 or 8 feet during the season. Some areas are subject to overflow, and some are covered with a thin overwash of lighter colored alluvial materials.

The native cover was mostly oak and brush, with willows and cottonwoods along the drainage channels. These soils have been cleared and are used for various field and orchard crops. Along Linda Creek, cherries are grown extensively, and good yields are obtained. Alfalfa, Ladino clover, and grain sorghum are also grown and produce well.

Chualar gritty loam, very gently sloping (0–2 percent slopes) (Cc).—The surface soil, a grayish-brown to dark grayish-brown gritty loam, extends to depths of 12 to 20 inches. It is friable when moist and hard when dry. The soil puddles easily, and plowsoles develop if it is tilled under unfavorable moisture conditions. The reaction is nearly neutral. The subsoil, extending to depths of 24 to 42 inches, is brown sandy clay loam or gritty clay loam. The subsoil is more compact than the surface soil and contains more clay. It breaks into irregularly shaped blocks coated with colloidal stains. The compaction does not greatly impede the penetration of roots and water.

The underlying parent material, which may extend to depths of more than 6 feet, consists of stratified grayish-brown gritty layers that range from coarse to moderately fine texture. Some rust-brown iron mottling occurs, particularly in the strata of finer texture. The grit in the profile consists of small angular fragments of quartz or feldspar derived from the disintegrated granitic rocks. Considerable mica also occurs.

This soil is intensively farmed, mostly to fruit but also to some field crops. Alfalfa and Ladino clover produced heavy yields. Cherries, the principal fruit, do very well. The soil is subject to some overflow in seasons of unusually high water. The overflow soon runs off and seldom does permanent injury. This flooding is detrimental, however, because it spreads many weed seeds, increases operating, costs, and materially decreases the value of the early alfalfa and clover crops.

Chualar gritty loam, channeled, very gently sloping (0–3 percent slopes) (Cb).—This inextensive soil occurs in association with other soils of the series as long narrow bodies along minor stream channels. The surface soil is grayish-brown or dark grayish-brown gritty loam. The subsoil is brown gritty clay loam or gritty heavy loam. The parent material consists of stratified gritty grayish-brown alluvium from granitic rock.

Although the stream channels usually carry water only at flood periods, they interfere with operation of farm equipment. Most of the areas are not farmed and are covered by trees, willows, or brush. Some are used for pasture.

Chualar gritty clay loam, nearly level (0–1 percent slopes) (Ca).—This soil is associated with Chualar gritty loam, very gently sloping, the Sacramento soils, and Columbia soils that are shallow over Sacramento soil material. The dark grayish-brown gritty clay loam surface layer breaks into firm or hard clods when disturbed and puddles easily when worked at unfavorable moisture content. The grit consists of small angular fragments of quartz or feldspar derived from granitic rocks. The subsoil, encountered at depths ranging from 10 to 20

inches and extending to 24 to 36 inches, is grayish-brown or gray gritty clay loam a little finer in texture than the surface soil. It is also somewhat more compact, and the aggregates are glazed with colloidal coatings. The profile is only slightly developed, and the moderately compact subsoil only slightly impedes root or moisture penetration. The reaction is nearly neutral throughout the profile. The underlying parent material consists of moderately fine to fine textured stratified gritty layers. There is some rust-brown iron mottling in the finer layers.

This soil is used mostly for grain, alfalfa, or Ladino clover. The alfalfa does well, and the Ladino clover and grain do very well. This soil is subject to occasional overflow, and water drains off more slowly than from Chualar gritty loam, very gently sloping. Clover appears to withstand this overflow better than alfalfa, which is frequently injured. The spreading of weed seeds by overflow waters is more serious on this soil than on Chualar gritty loam, very gently sloping, because most crops grown on this soil are not clean-cultivated.

COLUMBIA SERIES

In the Columbia series are alluvial soils recently accumulated from mixed igneous and sedimentary rock materials. In this area they occur mainly on the flood plains of the Sacramento River and lower part of the American, Cosumnes, and North Fork Mokelumne Rivers. They are usually flat, have a high water table for at least part of the season, and in places are subject to overflow. They are associated with Sacramento soils in the lower lying basin area.

Along the Sacramento, Cosumnes, and North Fork Mokelumne Rivers, most of the Columbia soils overlie the darker finer textured soils of the Sacramento series and, in some places, the Freeport series. Along the American River, however, they are 6 feet or more deep. The largest area of Columbia soils is in the American Basin. The fact that they occur over the older soils of the Sacramento and Freeport series indicates a probable recent period of alluvial deposition. Hydraulic mining in the latter part of the last century probably contributed materially to these deposits. Previous to this, alluvial deposition in the basin areas was slow enough to permit the accumulation of organic matter and the development of soils of the Sacramento and related series, except locally where a break in the river bank permitted rapid accumulation of sediment.

The noncalcareous surface soils are light brown, pale brown, or light yellowish brown. Their texture ranges from loamy fine sand to silty clay, and they contain considerable quantities of silt and some mica. The soils are friable, and even the finer textured ones break up readily to an excellent tilth. They do not puddle easily and may be worked at high moisture contents. Their reaction is usually near neutral. Rust-brown iron mottlings are frequent and may occur close to the surface. The subsoils consist of stratified layers of coarse- and medium-textured alluvium, highly mottled with rust-brown iron stains.

Under natural conditions these soils were subject to overflow during floods. Their normal vegetation consisted of willows, cottonwood trees, and brush, with a heavy grass cover in the somewhat open spots. Most of the soils are now protected from overflow and are cultivated to field and truck crops. Large high-quality yields are

obtained. On narrow strips adjacent to the Sacramento River, pears and some peaches are grown. Yields are high and the quality is good, but the acreage in orchards is restricted to the better drained areas extending not more than 300 or 400 yards from the stream channels. Here the soils occupy natural stream-built levees, and the water table is not so high as in the more nearly level areas farther from the stream channels.

Columbia loamy fine sand, nearly level (0–1 percent slopes) (CL).—This soil occurs chiefly in the northwestern part of the area. The surface soil, extending to depths of 10 or 20 inches, is light yellowish-brown or pale-brown, micaceous, slightly acid to neutral, single-grained loamy fine sand. The subsoil, extending to depths of 6 feet or more, is composed of stratified layers, mostly of sandy texture. Except for its more pronounced rust-brown iron mottlings, the subsoil is similar in color to the surface soil.

This soil is very friable and easily penetrated by roots and water. Smaller roots concentrate in the surface soil, but larger roots extend to considerable depths. Where farmed, this soil is used for alfalfa, fruit, and various field crops. Yields are good, but not so high as on the medium-textured soils in the same locality. Some areas that have stands of cottonwood trees and a grass undergrowth are used for pasture. The growth of grass is heavy and of good quality.

Columbia loamy fine sand, overflowed, nearly level (0–1 percent slopes) (CM).—A very small acreage of this soil occurs near the Cosumnes River. It is not fully protected by levees and is subject to overflow. It is used with associated bottom land soils, but could be used more intensively if it were more completely protected from overflow.

Columbia loamy fine sand, channeled, nearly level (0–1 percent slopes) (CK).—This soil is cut up by minor stream channels. Most of it occurs close to the Sacramento River where channeling has been severe. The area is now somewhat protected by levees. The channels therefore seldom contain water but are of sufficient size and number to interfere with farming.

The soil profile is similar to that of the Columbia loamy fine sand, nearly level. The natural vegetation consists mainly of cottonwood trees and grass; some channels are heavily covered with wild blackberry bushes. The soil is used only for grazing and, except where there are dense growths of blackberry bushes, produces very good forage.

Columbia loamy fine sand (over Freeport clay), nearly level (0–1 percent slopes) (CN).—This inextensive soil occurs some distance from the river. It consists of Columbia loamy fine sand underlain at depths of 2 to 5 feet by dark-colored clay soil of the Freeport series. The profile consists of pale-brown loamy fine sand surface soil over stratified sandy material mottled with rust-brown stains. The gray mottling just above the dark clay shows that water is held up by the less permeable underlying Freeport soil.

This soil is used both for orchards and field crops. Because of variation in depth to the clay substratum, its productivity for orchard crops and alfalfa is more variable than for shallow-rooted crops such as beans, tomatoes, and grain.

Columbia fine sandy loam, nearly level (0–1 percent slopes) (Ce).—This soil occurs mainly along the Sacramento and American Rivers. The largest area is near the mouth of the American River just north of the city of Sacramento. The surface soil is pale-brown or yellowish-brown micaceous, fine sandy loam of slightly acid to neutral reaction (pH 6.0 to 7.0). This layer is friable and may have a few rust-brown mottlings in the lower part. The subsoil, beginning at depths of 8 to 18 inches, consists of stratified, medium- and coarse-textured materials that are slightly lighter colored than the surface soil and more highly mottled with rust-brown iron stains. The subsoil is nearly neutral in reaction, loose to friable, and readily penetrated by roots and water. The rust-brown mottlings indicate an intermittent high water-table, but water passes through the soil freely.

Some of this soil near Sacramento is used for factory sites and homesites. It is excellent for general crop production, and is farmed on a commercial basis for orchard fruits, asparagus, corn, beans, tomatoes, and other field and truck crops. Yields are high and quality is good.

Columbia fine sandy loam, overflowed, nearly level (0–1 percent slopes) (Cf).—This soil occurs inextensively on the flood plain of the Cosumnes River; it is much like Columbia fine sandy loam, nearly level, but is overflowed almost every year. This limits its use to crops that are not greatly harmed by overflow, or to crops that can be planted after the period of flood hazard and will mature during the rest of the growing season. More adequate protection from overflow would allow a wider range of suitable crops.

Columbia fine sandy loam, channeled, nearly level (0–1 percent slopes) (Cd).—This inextensive soil occurs in narrow bodies along drainageways. It is unprotected by levees and consequently is subject to overflow by floodwaters that do considerable scouring and cutting of new channels. The profile is essentially the same as that of Columbia fine sandy loam, nearly level, but usually has a little more sand in the subsoil.

Because of periodic overflows, this soil has limited use. At present most of it is used for grazing. The dominant grass is Italian ryegrass, which grows luxuriantly and furnishes excellent summer pasture. Numerous oak and cottonwood trees along the channels furnish shade for stock during hot weather.

Columbia fine sandy loam (over Freeport clay), nearly level (0–1 percent slopes) (Cg).—This is an extensive soil in the American Basin in the northwestern part of the area. It consists of Columbia fine sandy loam underlain abruptly at depths of 2 to 5 feet by dark-colored clay soil material of the Freeport series.

A wide variety of field crops and some fruit are grown. Fruit trees do not do well where there is less than 3 feet of Columbia soil material. In general the soil is more suitable for shallow-rooted crops such as beans, grain, and tomatoes. Because the underlying Freeport soil material retards water and root penetration, the value of the soil is determined mainly by the thickness of the Columbia soil material.

Columbia fine sandy loam (over Sacramento silty clay loam), nearly level (0–1 percent slopes) (Ch).—Most of this soil occurs along

the Sacramento River very near the stream-built levees. A few small areas are along some of the sloughs and at the mouth of the Cosumnes River. This soil consists of Columbia fine sandy loam material abruptly underlain at depths of 2 to 5 feet by dark-gray finer textured soil material of the Sacramento series.

This soil is used for a wide variety of truck and field crops. Tree fruits are grown on some of the better drained areas near the natural levees of the Sacramento River. Yields are high, and the underlying Sacramento material does not seem to reduce significantly the productiveness of this soil. Some of the areas along the Cosumnes River used for pasture produce very good summer forage.

Columbia silt loam, nearly level (0–1 percent slopes) (Co).—This soil is associated with other soils of the Columbia series and the Sacramento soils. Normally it occurs closer to stream banks than the Sacramento soils. The surface soil extends to depths of 8 to 18 inches; it is a light-brown, pale-brown, or yellowish-brown friable silt loam, indefinite in structure but somewhat laminated in places. The surface soil works readily to a favorable tilth and rarely puddles even when worked at excessive moisture content. The lower part may be somewhat mottled with rust-brown iron stains.

The subsoil, extending to depths of more than 5 or 6 feet, consists of stratified soft silty layers of sediment of about the same color as the surface soil. The rust-brown mottlings, which are more common than in the lower part of the surface soil, become duller with depth and shade into an olive gray at 5 or 6 feet. This grayish coloration of the iron stains is more pronounced in the fine-textured strata. The profile is slightly acid to neutral and is micaceous throughout.

Under natural conditions, this soil was subject to overflow during periods of high water, but at present it is protected by levees and drainageways. It is an excellent soil, suitable for a wide variety of field and truck crops and for some fruit, especially pears. The yields are large, and crops are of high quality.

Columbia silt loam, overflowed, nearly level (0–1 percent slopes) (Cp).—In the southern part of the area and along the North Fork Mokelumne River occur bodies of Columbia silt loam subject to periodic overflow because of lack of levee protection. Overflow hazard limits the number of suitable crops. If protection were provided, this soil would be as productive as Columbia silt loam, nearly level. Hops are suitable because of the tolerance of the vines to some degree of overflow.

Columbia silt loam (over Sacramento silty clay loam), nearly level (0–1 percent slopes) (Cs).—This soil is more extensive than the nearly level Columbia silt loam and occurs along all of the major streams of the area. It consists of Columbia silt loam material underlain at depths ranging from 18 to 60 inches by dark-gray fine-textured soil material of the Sacramento series. The underlying, darker colored, finer textured Sacramento soil material is friable and only slightly less permeable to roots and water than the Columbia material above.

This soil is nearly as productive as Columbia silt loam, nearly level, and is used for a variety of vegetable and truck crops and for some fruit, particularly pears. Fruit crops are confined to locations close to the levees of the Sacramento River, where the water table is somewhat lower. Yields and quality of crops are high.

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Columbia silt loam (over Freeport clay), nearly level (0–1 percent slopes) (Cr).—This soil consists of Columbia silt loam overlying finer textured soils of the Freeport series, which occur at depths of 1½ to 5 feet. The underlying Freeport material is very dark-gray or black clay, mottled with gray or bluish-gray iron stains throughout. This material is much less permeable than the Columbia material above, and where it occurs at moderately shallow depths it greatly reduces productivity.

This soil is not extensive and is found only in the American Basin north of Sacramento. It is used for field and truck crops. Yields are somewhat less than on the Columbia soils but more than on the Freeport soil.

Columbia silty clay (over Sacramento silty clay), nearly level (0–1 percent slopes) (Cu).—This soil occurs extensively where the river flood plain is dissected by a number of channels and sloughs that contain water during most seasons. It consists of Columbia silty clay underlain at depths of 1 to 5 feet by dark-gray soil material of the Sacramento series. The overlying soil material is light-brown, pale-brown, or light yellowish-brown friable silty clay that works readily to a favorable tilth, and it does not puddle, even when cultivated under excessive moisture conditions. This material has some rust-brown iron mottlings, which begin near the surface and greatly increase below a depth of 6 inches.

The underlying Sacramento soil material is dark-gray or very dark gray, friable silty clay that is penetrated by roots and moisture as readily as the overlying Columbia material.

Nearly all areas are farmed. The soil is highly productive and can be used for a wide variety of field and truck crops. Alfalfa, beans, sugar beets, tomatoes, and grain sorghums are the principal field crops. Asparagus and winter peas are the principal truck crops. Some fruit, particularly pears, is grown close to the levees of the Sacramento River.

Farmed areas are drained by open ditches and are protected from overflow by levees. As in other soils of the series, the drainage and flood-control work is organized and carried out through reclamation districts.

Columbia silty clay (over Sacramento silty clay), overflowed, nearly level (0–1 percent slopes) (Cv).—This soil is subject to periodic overflow. It occurs rather extensively in the southern part of the area and on the Cosumnes River floodplain. Much of it is not farmed, and where uncleared it supports a fairly dense growth of oak trees with an undercover of wild roses, poison oak, and ash. Unfarmed cleared areas have a heavy growth of Italian ryegrass which affords very good pasture. Protection from overflow would make this soil fully as useful for irrigated crops as Columbia silty clay (over Sacramento silty clay), nearly level.

Columbia silty clay (over Freeport clay), nearly level (0–1 percent slopes) (Ct).—This soil consists of Columbia silty clay overlying dark-colored clay soil material of the Freeport series at depths of 1 to 4 feet. The Columbia soil is light-brown, pale-brown, or yellowish-brown silty clay that is friable and not easily puddled even if worked when excessively moist. There are a few rust-brown iron mottlings

near the surface and the number increases below 6 inches. Immediately above the clay material of the Freeport series, the iron mottlings are gray or olive-gray, indicating a prevailing perched water table and less aeration. The material under the Columbia silty clay is dark-gray clay mottled with gray or olive-gray iron stains; it is finer textured and less permeable to roots and water. Where this clay occurs at shallow depths the productivity of the soil is greatly reduced.

The soil is used mostly for field crops. The yields are somewhat better than those obtained from soils of the Freeport series but not so good as those from Columbia silty clay (over Sacramento silty clay), nearly level, or from other Columbia soils protected from overflow. A few fruit trees are grown, but they produce relatively poor yields.

CORNING SERIES

The soil of the Corning series occupies undulating valley areas along the eastern side of the Sacramento Valley. It occurs at elevations somewhat below those of the Redding soils, but above soils of the Perkins and San Joaquin series. It is a medium to strongly acid soil developed on old valley-filling gravelly and cobbly deposits.

The profile is strongly developed and deeply weathered. The pebbles and cobblestones range from less than 1 inch to 8 or 10 inches in diameter; they are well-rounded, very hard, and consist mainly of quartz, quartzite, and andesite, although some slate, sandstone, and granitic materials are present. In general, gravel is well scattered throughout the soil profile, but most of the cobblestones are found in the deeper stratified materials. The deposits are usually thick; many of the pits excavated by dredging for placer gold are 15 to 40 feet deep to the bottom of the gravelly materials.

The surface soil is reddish-brown, gravelly, and medium textured. The upper subsoil, encountered at depths of 6 to 18 inches, consists of gravelly materials of slightly finer texture than those of the surface soil, but is of similar color except for a slightly stronger reddish cast. The lower subsoil, which extends to depths of 30 to 60 inches, is red to reddish-brown gravelly clay that contains a high percentage of colloidal material. The underlying parent material is stratified, gravelly, and of variable texture, but the upper part is somewhat clayey and contains colloidal stains. The parent material is reddish brown, light brown, or yellowish brown, but the large quantity of pebbles and cobblestones gives it a grayish cast.

In some places this soil may be nearly neutral, and in others it may have a pH value as low as 5.0.

The natural vegetation consists mainly of annual grasses, though a few oaks grow on slopes and along some of the drainageways. The pasture is fair. The grasses are mainly ryegrass, with some bromegrass and alfileria. The original native cover was probably bunchgrass and some of the ryegrasses. Most of the bromegrass, foxtail, and wild oatgrasses now common are not native; they have been brought in deliberately or accidentally.

This soil is used mainly for range pasture or for dry-farmed grain which gives moderate yields. In a few areas grapes are grown under irrigation, but yields are low.

Corning gravelly loam, undulating (3–8 percent slopes) (Cw).—This soil is somewhat similar to the Perkins and Redding soils. It

occupies old valley terraces south of the American River and usually occurs at a higher elevation than the Perkins and San Joaquin soils but at lower elevations than the Redding soils. The relief is undulating, but short, steep escarpments occur at the edges of the terraces.

The surface soil, 6 to 18 inches deep, is strongly to medium acid (pH 5.0 to 6.0) reddish-brown gravelly loam. The surface inch may be slightly darker in color and less acid than the rest of the layer. Grass roots tend to concentrate at the surface, though they are numerous throughout the upper layer. The structure is weakly granular. On drying, the soil bakes hard, but it softens readily when moist and becomes sticky when wet. Some gravel is on or embedded throughout the surface soil.

The upper subsoil extends to depths of 18 to 36 inches; it is reddish-brown but slightly redder and slightly finer textured than the surface soil. A number of worm holes in the upper part of the layer make it more porous. Most of this material is slightly more compact than the surface soil, except where the latter has been puddled. Roots are less numerous than in the surface soil. The reaction is strongly acid to neutral (pH 5.0 to near 7.0). This layer is underlain by a lower subsoil that is the zone of greatest clay accumulation and that usually contains less gravel than any other part of the profile. The lower subsoil is red to reddish-brown clay of coarse blocky structure. The aggregates crumble readily when moist but are hard when dry. The crumbled material is somewhat flaky and has shiny colloidal coatings on the surfaces. Some dark-colored manganese stains occur in the lower part of this layer. In some places, but not everywhere, the reaction is somewhat less acid than in the surface soil and upper subsoil.

Below the lower subsoil is material that extends to depths of 30 to 72 inches, or an average depth of about 5 feet. This transition zone from the lower subsoil to deeper, less weathered material contains considerable clay and more gravel than the layer above. It is not so red, and becomes lighter with depth. More manganese stains occur in this layer than in any other part of the profile. The reaction is strongly acid to neutral, or usually about pH 6.0; the range is from about pH 5.0 to 7.0. This transitional layer is underlain by stratified gravelly and cobbly material that contains little interstitial soil and extends to considerable depth.

This soil is used mostly for pasture or dry-farmed grain, but also for grapes. The yields of grain are fair in more favorable seasons, but grape yields are poor. Much of the original area of this soil has been completely destroyed by placer dredging for gold. Dredging is still in progress and probably will continue until most of the soil has been destroyed for agriculture.

DORADO SERIES

Soils of the Dorado series occur in bands that roughly parallel the main axis of the hills bordering the Sacramento Valley. They are derived from slatelike bedrock, which in this area is made up mainly of schist and other metamorphosed rock. The rocks are not so thin-bedded as those forming the Whiterock soils and are somewhat lighter colored. The bedrock outcrops frequently along almost vertical cleavage planes. The soils, for the most part, are very shallow and usually have no profile development. In a few areas the soils are as

deep as 15 to 20 inches and have a thin layer of finer textured material immediately above the bedrock.

A sparse growth of grasses and other plants forms the native cover. The soils are used only for grazing. They occur on gently rolling to steep slopes, but erosion is not excessive. The bedrock of these soils may include gold-bearing quartz veins, and many areas have been disturbed by mining operations. In places these soils are closely associated with the soils of the Auburn series, but they are not so red or so deep.

Dorado stony silt loam, rolling and hilly (8–25 percent slopes) (DA).—The surface soil consists of reddish-yellow or light reddish-brown, medium acid granular stony silt loam. Many fine roots extend throughout the soil mass, but are concentrated slightly in the topmost part, which is a little darker. The surface layer, at a depth of 2 to 8 inches, grades into an indistinct subsoil that is slightly redder, has fewer roots, more worm or insect channels, and more slaty rock fragments than the surface soil. This subsoil layer rests abruptly at depths of 10 to 20 inches on the hard platy schists forming the parent bedrock. In places the surface soil and subsoil are very similar, Profiles that are 15 or 20 inches deep may have a thin layer of brown or yellowish-brown fine-textured material immediately above the bedrock.

Many outcroppings of jagged schistose and slatelike rocks occur through this soil. The outcroppings, which follow cleavage planes, run roughly parallel to each other in a northwest-southeast direction. The soils are covered by a sparse growth of annual grasses and are used exclusively for range pasture. They have about the same stock-carrying capacity as the corresponding phases of Whiterock stony loam but are only slightly better than the Amador soils, and inferior to all the other primary or residual soils of this area.

Dorado stony silt loam, steep (25+ percent slopes) (DB).—This soil occurs in association with the rolling and hilly Dorado stony silt loams and has a rough and steep relief. Bands of jagged schistose rocks outcrop frequently. The soil is very shallow, seldom more than 6 to 10 inches deep. The finer textured layer that occurs in some places where Dorado stony silt loam is deeper rarely occurs on these steep slopes.

The cover is sparse grass that dries up early in the season. It is used entirely for range pasture for cattle during the winter and spring. The stock is moved late in spring or early in summer to pastures higher in the Sierras.

FREEPORT SERIES

The soil of the Freeport series occupies a narrow band along the eastern margin of the valley trough. In places it extends for some distance up into the valley plain along those narrow drainageways where overflow waters of the Sacramento River back up during flood seasons. It also occurs in the American Basin in the northwestern part of the area. It is dark-colored, fine-textured, and somewhat transitional between soils of the Alamo and Sacramento series. The surface soil is neutral, and the subsoil is calcareous.

Where the Freeport soil borders the Alamo soil, it has a somewhat consolidated substratum at depths of 3 feet or more, but the upper part of the layer is much weathered and crumbled and highly calcareous.

The weathered zone is usually 6 to 18 inches thick. Farther out toward the valley trough, the depth to the substratum becomes greater, and the lower subsoil is olive gray, somewhat micaceous, and calcareous. To some extent this layer resembles the materials underlying the Sacramento soils, although it usually is more calcareous.

Where it occurs along the valley trough, this soil is farmed to grain, sugar beets, tomatoes and other truck crops, and, to small extent, alfalfa and Ladino clover. Yields are superior to those on the Alamo soil, but with the possible exception of tomatoes and other shallow-rooted truck crops, not so good as yields on the Sacramento soils. In the American Basin, Freeport soil is used for rice, sugar beets, Ladino clover, grain, and grain sorghum. The yields of rice are better than on the Alamo soil and about the same as on the Sacramento soils. The yields of sugar beets and Ladino clover are fairly good. Grain yields are relatively high.

Freeport clay (adobe), nearly level (0–1 percent slopes) (Fa).—This soil borders the valley trough and represents a transitional zone between the Alamo soil of the valley plain and the Sacramento soils of the valley trough. It appears as rather narrow bodies from Sacramento southward along the eastern edge of the valley trough and occurs in larger areas in the American Basin, usually between bodies of Sacramento and Alamo soils.

The surface soil, 8 to 16 inches deep, is gray or dark-gray clay. On drying, this clay develops deep cracks and shows a well-defined adobe structure of hard irregular blocks 8 to 14 inches across. The blocks break down into small angular or granular aggregates. When wet, this highly colloidal material absorbs water, becomes sticky, and swells, and the cracks disappear. This layer has a moderate quantity of organic matter and a nearly neutral reaction.

The upper subsoil extends to depths of 20 to 40 inches; it is a very dark-gray moderately compact clay. The main surface cracks extend down into this layer, but the secondary cracking and development of small aggregates similar to those of the surface soil are absent. This layer has a coarse blocky to somewhat prismatic structure. The large blocks are coated with colloidal glazing; and, though a number of roots penetrate the blocks, they have a tendency to concentrate in the cracks between blocks.

The lower subsoil is dark-gray clay somewhat mottled with rust-brown iron stains that grow duller with depth and eventually become gray or bluish-gray. This material is very fine and has some colloidal staining. It is seldom dry, but when dry it forms somewhat cubical blocks. In places the layer contains soft seams or hard pellets of segregated lime or gypsum, or both, and a number of buckshotlike iron pellets.

The underlying material, encountered at depths of 3 to 5 feet, is gray clay mottled with bluish-gray iron stains. This layer may be calcareous. At depths ranging from 3 to 8 feet, it may rest on a panlike substratum similar to that under the soils of the Alamo series. This substratum is crumbled and calcareous in the upper part.

South of Sacramento, this soil is used for grain, Ladino clover, sugar beets, and pasture. In the American Basin it is used for rice, grain, grain sorghum, sugar beets, and Ladino clover. Yields generally are superior to those on the Alamo soil but inferior to those on the Sacra-

mento soils. Pasture areas produce a heavy summer growth of Italian ryegrass, rushes, and various water grasses.

GLANN SERIES

The dark-colored Glann soil occurs extensively on the lower western margins of the valley plain. It has a relatively level surface and, where it borders the valley trough, represents a transition from the San Joaquin soils of the valley plain to the Sacramento soils of the valley trough. The water table is high, and the soil is subject to periodic overflow from the major streams.

The parent material for Glann soil is similar to that from which the moderately well drained San Joaquin soils have developed. The Glann soil differs from the Alamo soil in that the Alamo occurs in basinlike areas where surface drainage from San Joaquin soils accumulate, but there is no high water table. The texture of the Glann soil is not so fine as that of the Alamo.

Glann loam, nearly level (0–1 percent slopes) (GA).—This soil occurs along the lower margins of the valley plain bordering the flood plains of the Sacramento and Cosumnes Rivers, usually at elevations less than 10 or 15 feet above sea level. It has developed under the influence of a high water table and is subject to overflow.

The relief is nearly level but characterized by a few small mounds that normally do not rise more than 6 inches above the surrounding land. Toward the valley trough this soil is associated with soils of the Sacramento series and with Oakley loamy fine sand (over Glann loam), undulating. On the lower margin of the valley plain it occurs in association with the Alamo and San Joaquin soils.

The surface soil is 3 to 10 inches of dark grayish-brown loam, strongly to medium acid (pH 5.0 to 6.0). It is friable when moist but dries out fairly hard. Many fine grass roots are concentrated in this layer.

The upper subsoil, extending to depths of 12 to 24 inches, is gray or light-gray sandy clay loam. This layer has many fine pores, some of them vesicular, but does not have so many roots as the surface soil.

The lower subsoil reaches to depths of 24 to 60 inches; it is a grayish-brown sandy clay or clay, mottled in the upper part with rust-brown iron stains. The mottlings become less bright with depth, and in the lower part of this layer they are bluish gray. On drying, the lower subsoil has a somewhat cubical structure, and the individual aggregates are heavily coated with colloidal material. In some places, the bluish-gray mottlings occur chiefly in cracks between aggregates. This layer also has many iron pellets shaped like buckshot. The underlying substratum may be hard like that under the San Joaquin soils, or it may be somewhat less firmly consolidated.

This soil normally has a grass cover, mostly Italian ryegrass and some bromegrass, that furnishes fairly good summer pasture. Where protected from overflow, the soil is used extensively for Ladino clover, which produces very good yields. Asparagus and truck crops are also grown to some extent, but yields are not so good as on the Sacramento and other basin soils.

HANFORD SERIES

The Hanford series consists of soils derived from recent alluvium deposited along the flood plains of the American and Cosumnes

Rivers. They are medium- to coarse-textured highly stratified soils that show no indication of profile development. The parent material is alluvium derived mainly from granitic rocks but to some extent from basic igneous and sedimentary rocks. The soils are nearly neutral in reaction; they formed in a manner similar to that for soils of the Columbia series but occur farther upstream on the flood plains of the rivers. The water table is not so high, and the mottling characteristic of the Columbia soils is missing.

The surface soil consists of micaceous medium- to coarse-textured very friable materials that break readily to granules or single grains under cultivation. To considerable depth the subsoil consists of stratified layers of sandy or medium-textured materials of slightly lighter color than the surface soil. The profile is porous, friable, and easily penetrated by roots and water.

The Hanford soils are used for a wide variety of fruit, field, and truck crops. Among the fruits are peaches, pears, apricots, plums, and prunes, all of which produce excellent yields of high-quality fruit on the typical medium-textured soils of this series. The principal field crops—alfalfa, grain sorghum, beans, sugar beets, hops, and a wide variety of truck crops—also give large high-quality yields.

Hanford sand, overflowed, nearly level (0–1 percent slopes) (HD).—This inextensive soil occurs as narrow bands extending into areas of Hanford very fine sandy loam or Hanford loamy fine sand. The surface soil consists of loose single-grained, micaceous, brown sand, the grains of which are almost uniformly of medium and fine size. The subsoil is light-brown or pale-brown sand, also loose and single-grained. The reaction is nearly neutral throughout the profile. Barren surfaces are easily disturbed by winds and develop small wind ripples.

This soil is distinctly inferior to either Hanford very fine sandy loam or Hanford loamy fine sand. It is difficult to establish stands of alfalfa because of wind. The blowing sand either buries or cuts off the tiny plants. Yields of alfalfa or other field crops are decidedly inferior, even after stands are established. In addition, this soil is subject to periodic overflow.

Hanford loamy fine sand, nearly level (0–1 percent slopes) (HB).—This soil occurs extensively on the flood plain of the American River. It is fairly level, yet cannot be irrigated without being leveled. The surface is brown, loose loamy fine sand in which some loamy very fine sand is included. Although the texture is coarse, it is uniform and contains very little grit. The subsoil, which occurs at depths ranging from 12 to 24 inches, has a similar texture but is slightly coarser and becomes increasingly so with depth. It is stratified and extends to depths of more than 6 feet.

The entire soil is nearly neutral in reaction. Though loose and very permeable throughout it does not appear to be especially droughty.

This soil is effectively protected from overflow by comparatively small levees. Water for irrigation is either pumped directly from the river or from shallow wells.

All of this soil is intensively farmed. Good or very good yields of fruit, hops, alfalfa, and a wide variety of truck crops are obtained. Ladino clover does not do well on this soil because it is shallow-rooted and requires frequent irrigations.

Hanford loamy fine sand, overflowed, nearly level (0–1 percent slopes) (Hc).—This soil occurs rather extensively on the flood plain of the Cosumnes River. Some areas are more adequately protected from overflow than others, but overflow hazard generally is greater than for Hanford loamy fine sand, nearly level. The soil is potentially suitable for intensive crop production, but suitability of crops is limited so long as overflow occurs. Because of its relative tolerance to overflow, hops is a crop fairly well suited to the soil under present conditions.

Hanford loamy fine sand, channeled, nearly level (0–1 percent slopes) (Ha).—This soil occurs along both the American and Cosumnes Rivers between the main river channel and the protecting levees, or along smaller distributary channels that carry off some of the overflow water. The bodies are not large but fairly numerous. They consist of areas of Hanford loamy fine sand in which numerous channels scoured by floodwaters break up the evenness of the surface. The surface soil is similar to that of Hanford loamy fine sand, nearly level, but the subsoil may have a coarser texture. The color gradually becomes lighter with depth.

Most of these areas are not farmed but are used for pasture. The plant cover consists of oak and cottonwood trees, brush, willows, blackberry briers, and grasses, chiefly Italian ryegrass, which grows luxuriantly and produces good forage.

Hanford very fine sandy loam, nearly level (0–1 percent slopes) (Hf).—This soil occurs mainly along the flood plain of the American River. It has a brown, friable, very fine sandy loam surface soil that is nearly neutral in reaction and contains considerable mica.

The subsoil, which extends from a depth of 1 or 2 feet to more than 6 feet, is loose, stratified, micaceous, medium-textured, brown or pale-brown material that becomes increasingly coarser with depth.

This soil was once subject to overflow but is now protected by levees, which are not required to be so large as for the Columbia soils farther down stream. Irrigation water is pumped from the American River or from shallow wells on the flood plain a short distance from the stream channel.

This soil is one of the most productive in the area. It is suitable for any crop that will grow in the locality and is used for a wide variety of fruit, field, and truck crops.

Hanford very fine sandy loam, overflowed, nearly level (0–1 percent slopes) (Hg).—This soil occurs entirely on the flood plain of the Cosumnes River and is subject to periodic overflow. The intensity of overflow depends on amount of protection provided. Potentially, the soil is excellent for a wide range of crops, but hazard of overflow now limits intensity of use. Hops, alfalfa, and fruit trees are grown and normally are not seriously damaged by overflow, because the water usually drains off rapidly. The floodwater does tend to scatter weed seeds, limit the number of suitable crops, and reduce yield or quality, or both, of the crops grown.

Hanford very fine sandy loam, channeled, nearly level (0–1 percent slopes) (He).—This soil occurs as a number of small narrow strips between the protecting levees and the main river channel or along both sides of smaller channels. The strips are divided by small

distributary channels or temporary courses cut by overflow water. The surface soil is brown friable micaceous very fine sandy loam underlain by stratified layers of similar texture and color that become lighter in color with depth. The reaction throughout the entire profile is nearly neutral.

Its principal use is for pasture. There are some oak and cottonwood trees and an undercover of grass, or areas covered by small willows or blackberry briers. Grassy areas are covered by a heavy growth of Italian ryegrass, which makes good forage.

HOLLAND SERIES

The inextensive soil of the Holland series occurs in the northeastern part of the area. It developed in place from granitic rock, mostly granodiorite. It has a brown or grayish-brown slightly acid surface soil and a neutral to slightly acid subsoil slightly lighter in color. The soil is moderately deep. Parent material—brown, grayish-brown, or reddish-brown decomposing granitic rock—occurs at a depth of 20 to 48 inches. The bedrock is for the most part deeply weathered and pervious to moisture. There is sufficient profile development to produce distinct horizons. The relief is rolling and hilly; slopes are gentle to moderately steep. Under native conditions, erosion is not excessive, but it is often destructive on cultivated areas. The virgin cover consists of trees, mostly oak and digger pine, and some brush. The grass undercover is not especially heavy, yet it makes fairly good pasture.

The soil of this series is related to the soils of the Siskiyou series. It is closely associated with Siskiyou soils but has a more strongly developed profile. It is also associated with the redder, finer textured Auburn soils, which are derived from basic igneous rock and amphibolite schist.

Holland sandy loam, rolling and hilly (8–25 percent slopes) (Hh).—The surface soil is 6 to 15 inches of brown or grayish-brown slightly acid, friable, gritty, micaceous sandy loam of granular structure. The upper part of this layer is slightly darker, and there may be a slight accumulation of organic litter on the surface.

The subsoil, extending to depths of 20 to 48 inches, is brown slightly acid gritty sandy loam or loam, usually of slightly finer texture than the surface soil. Although fine roots are less numerous than in the layer above, there are many large coarse roots in the subsoil. More worm and insect channels occur, particularly in the upper part, than in the surface soil. The structure is more or less indistinct, but there are some colloidal stainings, and the aggregates are slightly harder than in the surface soil. The lower subsoil grades into crumbling, weathered granitic bedrock. The zone of weathering may extend to 5 or 20 feet, and the weathered material is loose and easily penetrated by water. Some of the coarser roots of trees and brush extend into this material.

The native vegetation consists of trees and some undercover of grass. The soil is used mainly for range pasture, which is fairly good. Some areas have been cleared and used for tree fruits of various kinds. The orchards are small, and the growth of the trees irregular. Yields are only fair, but the quality of fruit is good. On the State prison farm near Folsom, this soil is used for a wide variety of truck and field crops, but yields are relatively low. Severe erosion

takes place on cultivated fields left bare during the rainy season. Even cover crops and weeds will not entirely control erosion on these areas. The cover in pasture areas effectively controls erosion, despite the rolling to hilly relief. Because irrigation water is difficult to obtain and the fields are hard to irrigate, irrigation of crops is being abandoned, and the soil is being allowed to revert to pasture.

HONCUT SERIES

The soils of the Honcut series occur on the flood plains along the smaller streams and along the American River. They are brown to reddish-brown recent alluvial soils. The alluvium came chiefly from basic igneous rock, but also from some sedimentary and acid igneous rocks. The soils are slightly acid to slightly basic (from pH 6.0 to about pH 7.5), nearly level, and somewhat dissected by small stream channels.

The subsoil, to depths of 24 to 42 inches, consists of brown or reddish-brown stratified layers of alluvium similar to that of the surface soil but usually somewhat lighter colored and, in places, slightly more reddish. There is little or no evidence of profile development. Roots and water penetrate these permeable and friable materials freely, although under natural conditions the roots of shallow-rooted grasses are concentrated in the upper few inches. The underlying parent material consists of stratified layers of variable textured, loose and friable, light-brown sediments that extend to depths of 6 feet or more.

The soils are not extensively cultivated, mainly because of lack of water for irrigation. Where farmed, they are planted mainly to alfalfa and Ladino clover for use as hay or pasture for dairy cattle. Some areas are planted to fruit and truck crops. Yields are very good, and these soils could be further developed for intensive farming if an adequate water supply were assured.

Honcut very fine sandy loam, nearly level (0–1 percent slopes) (Hp).—This soil occurs as narrow stringers along a few creeks in the northern part of the survey. The surface soil is brown or reddish-brown, friable, granular, very fine sandy loam. It works to a favorable tilth that is easy to maintain. The reaction is slightly acid to neutral (pH 6.0 to 7.0). The subsoil is friable and similar to the surface soil in texture but slightly lighter color and is somewhat more porous. Usually this layer contains many worm holes, and the walls of some of these are slightly glazed with colloidal stains. The subsoil breaks into soft granules. Its reaction is very slightly acid (pH 6.5 to 7.0). The parent material consists of friable, brown or light-brown slightly stratified layers of medium-textured sediments that in places contain mica. The reaction is neutral (pH 6.5 to 7.5).

This is an excellent agricultural soil, but the few areas under cultivation are planted chiefly to dry-farmed grain. Most of the soil is used as pasture for cattle or sheep. The native cover is grass and scattered oaks. This soil has the same use capabilities as Hanford very fine sandy loam, and if irrigation water were available, it would be suitable for a wide variety of field, fruit, and truck crops.

Honcut very fine sandy loam, overflowed, nearly level (0–1 percent slopes) (Hr).—This soil occurs along Dry Creek on the southern boundary of the area. It is subject to periodic overflow and little is

cultivated. It is used mainly for pasture. The grasses, chiefly Italian ryegrass, grow luxuriantly and furnish excellent pasture. Although the overflow comes from Dry Creek, this stream does not flow during summer and cannot be considered a reliable source of water for irrigation. If protected from overflow and provided with irrigation water, this soil would produce a wide variety of crops.

Honcut very fine sandy loam (over Bear Creek gravelly loam), overflowed, very gently sloping (0–3 percent slopes) (Hs).—This relatively inextensive soil occurs along Laguna Creek not far from Clay. It is subject to periodic overflow and occupies the flood plain of the creek, a few feet lower than the low terraces on which occur the San Joaquin soils. It consists of areas of Bear Creek gravelly loam soil material over which Honcut very fine sandy loam has been deposited. The Honcut soil material is seldom more than 15 to 18 inches deep, and is usually about 10 or 12 inches. It is pale-brown or yellowish-brown, friable, and somewhat stratified. Textures are variable within short distances, but the material is for the most part, very fine sandy loam. This material rests abruptly upon grayish-brown Bear Creek soil material, which is underlain by a subsoil of similar material but of slightly lighter color and more porous character. Below the subsoil occurs stratified, gravelly, light-gray or light brownish-gray material.

This soil has a somewhat better surface layer than the Bear Creek gravelly loam, very gently sloping, and gives superior yields of dry-farmed grain and grain hay. It also produces better pasture than Bear Creek gravelly loam, very gently sloping. The soil is inferior to Honcut very fine sandy loam, nearly level, but it would be suitable for irrigated agriculture if it had a dependable water supply and were protected from overflow.

Honcut loam, nearly level (0–1 percent slopes) (Hm).—The surface soil is brown or reddish-brown friable loam that works easily to a granular structure or soft clods under cultivation. The reaction is slightly acid to neutral (pH 6.0 to 7.0). The subsoil at depths ranging between an upper limit at 8 to 16 inches and a lower limit at 24 to 30 inches is similar to the surface soil in color and consistence, but is somewhat more porous. It contains numerous worm and insect channels, and some of the surfaces are slightly glazed with darker colored colloidal stains. The reaction is nearly neutral. The underlying, somewhat stratified material is light-brown, medium-textured, and friable. It becomes gradually lighter in color with increased depth. The reaction is neutral or slightly basic.

Near Perkins this soil is irrigated and used for fruit, vegetable, and field crops, which give good yields. The acreage in orchards—principally in pears, peaches, plums, prunes, and grapes—is probably greater than that in other crops. Grapes appear to do particularly well in comparison with vines of the same variety and similar age on soils of the San Joaquin series on the same locality, and they compare favorably with the excellent vines grown on Hanford soils of the Mokelumne River fan near Lodi (in San Joaquin County). Near Perkins, irrigation water can be obtained easily from wells or by lifting the water 20 to 30 feet directly from the American River.

The alluvial plain on which this soil is found formerly extended eastward almost to Folsom, but the eastern half has been destroyed by gold dredging.

Honcut loam, overflowed, nearly level (0–1 percent slopes) (Hn).—Along Coyote and Carson Creeks, Honcut loam is subject to periodic overflow. Very little of this overflowed soil is intensively cultivated, mainly because irrigation water is lacking. Were such a supply available and the soil protected from overflow, it would be productive of a wide variety of crops. It is now used for pasture or dry-farmed grain.

Honcut loam, channeled, nearly level (0–1 percent slopes) (Hl).—This soil occurs in long narrow strips along small drainageways. It is cut by minor shallow stream channels which carry overflow water during periods of high water but are usually dry at other times. The surface soil is brown to reddish-brown friable loam underlain by a more porous subsoil, which is slightly redder but similar in texture and structure. The deeper material consists of stratified light reddish-brown soil materials of medium or moderately fine texture.

The soil is used almost exclusively for range pasture and produces forage similar to that on Honcut loam, nearly level. Cottonwood trees and willows growing along the stream channels provide shade for livestock and help keep the channels from shifting.

Honcut loam (over San Joaquin hardpan substratum), nearly level (0–1 percent slopes) (Ho).—This inextensive soil is underlain at depths of 24 to 60 inches by a hard, moderately consolidated substratum like that under soils of the San Joaquin series. The surface soil is brown or reddish-brown friable loam that easily works to a favorable tilth. The subsoil is of similar texture, slightly lighter in color and more porous, and contains numerous worm and insect channels. Directly under the subsoil is a consolidated substratum that is impervious to roots and water.

This soil represents a transition from areas of San Joaquin soils to areas of Honcut loam. The Honcut soil material above the hardpan substratum averages about 3 feet, which is sufficient for growth of a wide variety of crops. Considerable fruit is grown on this soil. Fruit trees do well but not so well as on Honcut loam, nearly level. Nevertheless, fruit production is far superior to that on San Joaquin loam in the same general locality. Beans and tomatoes also do very well, as do many other truck crops.

Honcut gravelly loam, nearly level (0–1-percent slopes) (Hk).—This inextensive soil occurs in the eastern part of the area as long narrow winding strips along small creeks and drainageways. The surface layer is reddish-brown or brown gravelly loam, somewhat redder than that for other types in this series. The soil is porous and friable, but its workability depends largely upon its gravel content, which varies within short distances. The gravel consists chiefly of andesitic rocks, but some is quartz or quartzite and some slate. The individual pieces are somewhat angular, which indicates that they have not been transported far. The reaction is slightly acid to neutral (pH 6.0 to 7.0).

The subsoil begins at depths of 8 or 20 inches and extends to 24 or 36 inches. It is a reddish-brown permeable gravelly loam with a large

number of worm and insect channels. Some of the surfaces of the channels are glazed with colloidal stains. The quantity of gravel is variable but is usually equal to that in the surface soil. The reaction is about neutral (pH 6.5 to 7.0+).

Under the subsoil are light reddish-brown, stratified, variable but generally medium-textured gravelly materials that normally extend to depths of 6 feet or more and have a nearly neutral reaction. The parent material is alluvium washed mainly from soils of the Auburn and Dorado series.

This soil is used for pasture or for dry-farmed grain hay. The pasture is far superior to that on the soils that developed on bedrock. Yields of grain hay are extremely variable and depend more on the quantity and distribution of seasonal rainfall than on the soil.

This soil would be favorable for agriculture if irrigation water were available, but even water for livestock is sometimes scarce in these localities. Because the soil is gravelly, it is difficult to till, and is less suitable for field or truck crops. The gravel should not hinder use for orchards, if irrigation water can be obtained.

KITCHEN MIDDENS

Kitchen middens (Ka) is a miscellaneous land type that occurs along the Sacramento, Cosumnes, and North Fork Mokelumne Rivers and some of the associated sloughways. It consists of low mounds of debris accumulated during a relatively long period of Indian occupation. The material is generally darker colored than the surrounding soils, friable, and highly calcareous. It contains numerous clamshells or clamshell fragments, considerable quantities of ashes and bones, and some remnants of pottery, arrowheads and spearheads, grinding bowls, and other Indian artifacts. Most of the Kitchen middens are along the Cosumnes River and are either left unused or pastured. They occur as mounds on alluvium of the flood plains and on San Joaquin soil material.

OAKLEY SERIES

The inextensive soils of the Oakley series occur as narrow ridges or mounds surrounded by the lower lying soils of the Sacramento and Glann series. They have developed from sandy materials that were probably deposited by water but later modified considerably by wind. The wind action probably accounts for their gently undulating relief. The soils have no profile development; they are slightly acid in the surface soils and nearly neutral in the subsoils.

The surface soils are pale brown or grayish brown, single-grained, and normally coarse-textured. Most of the roots are concentrated in the surface layer. The color becomes somewhat lighter as depth increases. The subsoils consist of pale-brown or light yellowish-brown loose sand or fine sand of single-grained structure and nearly neutral reaction. The underlying material is light yellowish-brown sand that is loose and very rapidly permeable. Roots do not penetrate deeply into this sand, probably because moisture is lacking. The cover is mostly grass.

Oakley sand, undulating (3–8 percent slopes) (Ob).—This inextensive soil occurs mainly in one body located a short distance from Walnut Grove. It occupies a low sandhill surrounded by Sacramento

soils. The surface soil, 12 to 20 inches deep, is pale-brown or grayish-brown, single-grained, slightly acid sand. In undisturbed areas roots of shallow-rooted grasses have concentrated in a thin darker-colored layer at the immediate surface, but they decrease rapidly with increased depth. The subsoil is pale-brown or light yellowish-brown, loose, single-grained sand that gradually becomes lighter with depth. Throughout the profile the sand grains are of fairly uniform medium or fine size.

Most of this soil is used for the farmstead, corrals, and pasture on a moderately large ranch. Although the forage is not particularly heavy, it provides satisfactory grazing during the rainy season when the associated Sacramento soils are very wet and muddy. A few acres were planted to grapes, but these have been removed.

Oakley loamy fine sand (over Glann loam), undulating (3–8 percent slopes) (OA).—This soil occupies small ridges or mounds above soils of the Glann series along the western edge of the valley plain lying east of the valley trough. The undulating ridges run roughly parallel to the axis of the valley. The soil consists of material derived from Oakley loamy fine sand that has been deposited over Glann soil material. The sandy material was undoubtedly deposited by the stream and later modified by wind action.

The surface soil is 12 to 36 inches of light brownish-gray or pale-brown very friable loamy fine sand of single-grain or weak granular structure. Where this layer is deep, it becomes lighter colored with increased depth. Its reaction is nearly neutral. The subsoil, extending to depths of 30 to 60 inches, consists of grayish brown, nearly neutral, loamy fine sand or fine sandy loam that is slightly brittle when dry. This layer has considerable rust-brown iron mottling, which probably results from an intermittently perched water table over the less pervious substratum.

The substratum consists of clay loam or sandy clay loam that may or may not be underlain by semiconsolidated layers. This substratum is grayish brown or yellowish brown and has considerable rust-brown and some olive-gray iron mottlings. It is compact and contains many small iron pellets. These pellets are usually 0.1 to 0.2 inch in diameter and of concretionary structure. The pellets show concentric rings, usually about a small sand-grain nucleus. In places, there may be some seams of segregated lime or gypsum in the lower part. The reaction of the substratum is slightly basic.

About half of the area is farmed, mostly to alfalfa or Ladino clover, which do well. Other areas are used only for pasture, which is superior to that on the associated Glann soil.

PENTZ SERIES

Soils of the Pentz series normally occur in small bodies on rolling to hilly relief in the eastern part of the area. They are derived from soft tuffaceous sandstone, mainly of andesite, which looks like sandstone of the Ione formation but is of more recent origin. The soils are of moderate depth; and, though they appear to have accumulated very little clay in their subsoils, they generally show several distinct layers.

The surface soils, 4 to 12 inches deep, are grayish-brown, medium-textured, and granular. Many very fine pores occur, especially near

the surface, where the material is darker in color and contains more organic matter. This thin layer nearest the surface often has a platy structure and is usually nearly neutral, whereas the reaction of the rest of the surface soil is medium acid to neutral (pH 5.5 to 7.0). Most of the grass roots are concentrated in the surface layer. The subsoils, extending to depths of 15 to 50 inches, consist of grayish-brown or light brownish-gray materials that have no definite structure but a texture similar to that of the surface soils. The subsoils are friable and normally contain many worm and insect channels. Roots extend into them but are not so numerous as in the surface soils, and their number decreases rapidly with depth. The pH is 5.5 to 7.0.

The upper parent material is weathered, easily crumbled, sandstone that may be 2 or 3 feet in depth. It is soft and weakly consolidated, rarely hard and brittle. The crumbling bedrock is usually a little less acid than the soil material above (pH 6.0 to 7.0).

The plant cover on these soils consists of grasses and a few trees. Most of the grasses are annuals; they grow more luxuriantly than on any of the other residual soils with the possible exception of the Whitney. Soft chess, the dominant species, makes good forage. The soils are erosive, and considerable sheet and gully erosion has developed. The relief is variable; some of the slopes are steep, but usually short.

The Pentz soils are closely related to and closely associated with the Peters soil, which is derived from the same type of formation, but usually from finer textured materials. The Peters soil is darker in color than the Pentz soils and usually has an adobe structure. The Pentz soils are also closely associated with soils of the Redding series. In many places the material forming the Redding soils occurs on the top of the formation that gives rise to the Pentz soils. In these localities the Pentz soils generally include some of the hard well-rounded gravel that is a remnant of the material from which the Redding soils developed.

Pentz soils are used almost entirely for pasture, but their gentler slopes are suitable for dry-farmed grain. They are erosive under cultivation and must be managed carefully if severe erosion is to be prevented.

Pentz sandy loam, rolling and hilly (8–25 percent slopes) (PF).—This soil occurs in small bodies closely associated with soils of the Redding, Peters, and Amador series, and with other soils of the Pentz series. The surface soil is 6 to 20 inches of grayish-brown, friable sandy loam of weak granular structure and medium acid to neutral reaction (pH 5.5 to 7.0). Many grass roots occur throughout this layer, but they tend to concentrate in the topmost inch, which is darker and often less acid than the rest of the surface layer. The subsoil consists of friable grayish-brown or light brownish-gray sandy loam that has many more root and insect holes than the surface soil. Its reaction is about the same or slightly less acid than that of the surface soil. The parent bedrock of light-gray or pale-brown, softly consolidated tuffaceous sandstone occurs at depths of 20 to 48 inches. Although the rocks are loosely consolidated, the weathered zone is not thick.

This soil occurs where livestock raising predominates, and most of it is satisfactory for pasture. Soft chess is one of the most common grasses; other plants are ripgut grass, alfileria, and burclover. These

grow well, and, except for ripgut grass, furnish good pasture. This soil is fairly erosive. Some erosion takes place wherever it is overgrazed, but properly managed pastures erode only slightly. The soil is suitable for dry-farmed grain or grain hay and for other crops such as those grown on the Whitney soils.

Pentz sandy loam, steep (25+ percent slopes) (PG).—This soil occupies areas where most of the slopes are steep, short, and in places precipitous. The soil is shallower than the rolling and hilly phases of Pentz sandy loam, and the forage is not so heavy.

The surface soil is grayish brown; the subsoil is a grayish-brown or light brownish-gray sandy loam. Softly consolidated sandstone bedrock occurs at depths ranging from a few inches to 3 or 4 feet but normally is not far below the surface.

This soil is used entirely for pasture. Because of its steeper slopes and less dense plant cover, it is more erosive than the rolling and hilly phases of Pentz sandy loam.

Pentz loam, rolling and hilly (8–25 percent slopes) (PA).—This soil occurs as small bodies in the eastern and east-central part of the area. It is associated with other soils of its own series and with soils of the Peters, Redding, and Amador series. The surface soil is 6 to 18 inches of grayish-brown or dark grayish-brown loam. When disturbed, this friable layer breaks into granular aggregates. It contains many grass roots, some of which are concentrated in a thin zone near the surface. This thin topmost zone is slightly darker than the rest of the surface layer and nearly neutral in reaction. The rest of the surface layer is strongly to slightly acid in reaction (pH 5.0 to 6.5).

The subsoil is similar to the surface soil in texture but somewhat lighter colored, more porous, and slightly less acid (pH 5.5 to 7.0). It has many worm and insect channels but not so many roots as the layer above. The bedrock—a soft, light-gray or pale-brown, shaly or fine-grained tuffaceous sandstone—may occur at depths ranging from 18 to 48 inches but is usually found at 24 to 30 inches.

This soil is among the best for pasture in the area. It produces good stands of high-quality forage consisting of annual grasses and some burclover and alfileria. Where overgrazed, the soil erodes slightly, but not so severely as Pentz sandy loam, rolling and hilly.

Pentz loam, steep (25+ percent slopes) (PB).—This soil occupies short steep slopes along escarpment rims. It is similar to Pentz loam, rolling and hilly, but normally shallower and more variable in depth. It ranges from a few inches to 2 or 3 feet deep, but commonly is less than 18 inches.

This soil is used only for pasture, and produces less forage than Pentz loam, rolling and hilly. Erosion is greater than for the rolling and hilly Pentz soils, but is excessive only if the soils are overgrazed.

Pentz-Redding gravelly loams, rolling and hilly (8–25 percent slopes) (PC).—This moderately extensive complex of Pentz and Redding soils usually occurs on slopes or lower ridges, as the higher ridges are capped with the gravelly materials from which Redding soils have developed. The Redding soil of this complex generally conforms to the description of Redding gravelly loam, undulating and rolling, although in several places the soil is transitional between the Pentz and Redding series. Remnants of Redding soil material

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account for much of the gravel in the Pentz soils of the complex, as well as for their color, which is browner than is typical for the Pentz series.

The surface layer of the Pentz soil in this complex is 6 to 12 inches of grayish-brown or brown gravelly loam. The gravel consists mostly of rounded quartz or quartzite, though some came from basic igneous rock. The surface soil is less friable than is normal for the Pentz series; it is hard when dry. Grass roots are numerous throughout the surface layer but tend to concentrate at the immediate surface, where the material is slightly darker than in the rest of the surface layer and usually slightly less acid.

The upper subsoil consists of brown or grayish-brown gravelly loam or gravelly clay loam, which has many fine worm and insect channels and is considerably more porous than the surface soil. Fewer roots penetrate this layer. The lower subsoil consists of brown or grayish-brown, moderately compact, gravelly clay loam or gravelly clay, which is fairly sticky when wet but dries to a hard blocky condition.

The reaction throughout the soil profile ranges from strongly acid to neutral, with the more acid reaction in the lower surface layer. The parent bedrock consists of softly consolidated fine-grained sandstone similar to that underlying Pentz loam, or of softly consolidated conglomerate.

This complex is used only for grazing. The forage is good on the Pentz soil, but not so heavy as on other soils of that series. The gravel appears to afford some protection against erosion. About 60 percent of the complex consists of Pentz gravelly loam; the rest is Redding gravelly loam, with a few small inclusions of Peters clay.

Pentz-Redding gravelly loams, steep (25+ percent slopes) (PD).—This complex occurs in small narrow bands, usually along the sloping sides of old benches that are capped with Redding soil materials. Slopes are short but steep. This complex consists of fairly shallow soils having profiles much more variable than those for corresponding soils in areas with more gentle slope. Nevertheless, general soil conditions are similar to those described for Pentz-Redding gravelly loams, rolling and hilly.

The complex is used entirely for range pasture, mostly for cattle. The forage is not so good as on Pentz-Redding gravelly loams, rolling and hilly. Overgrazed areas show considerable evidence of erosion, but those properly managed are only slightly eroded.

Pentz-Redding gravelly loams, undulating (3–8 percent slopes) (PE).—This complex occupies areas with less steep relief. The soils are similar to those of the Pentz-Redding gravelly loams, rolling and hilly. They are eroded very little and produce good pasture.

PERKINS SERIES

The soil of the Perkins series is slightly acid. It developed on stream benches from valley-filling materials similar to the parent materials for Corning and Redding soils. It is located at slightly higher levels than the associated Honcut soils, which are closer to the river. The Perkins soil is gravelly, the gravel consisting mostly of quartz, quartzite, and andesite rocks, but also of some slate, sandstone, and granitic materials.

The surface soil is brown or light brown, and the upper subsoil is reddish brown and slightly finer textured than the surface soil. The lower subsoil is also reddish brown, but somewhat more reddish than the upper subsoil. The lower subsoil has moderately fine texture, is considerably more compact, and has more colloidal staining than the soil above. The underlying parent material consists of alluvial deposits of stratified, brown, well-rounded gravel, through which few roots penetrate. The reaction is nearly neutral. These gravelly deposits are fairly deep and are gold-bearing. At the time of survey, gold dredging was being carried on in these deposits at several places.

The natural cover on the soil is grass, and the production of forage is fairly high. Most of the areas, however, are farmed. Dry-farmed grain is grown where no irrigation water is available, and yields are generally better than from soils of the Corning, Redding, or San Joaquin series. Where the soil can be irrigated, pears, peaches, apricots, grapes, and walnuts are grown. The yields are fair but not so good as those obtained on the Honcut and Hanford soils of the same locality. A wide variety of truck and field crops is also grown, and the yields of these are moderately high but slightly inferior to those on the Honcut and Hanford soils.

Perkins gravelly loam, very gently undulating (0–3 percent slopes) (Ph).—This soil occupies low, very gently undulating terraces lying below the Corning soil and on the same plain as the San Joaquin soils. The surface soil is 6 to 18 inches of brown or light-brown gravelly loam of slightly acid to neutral reaction (pH 6.0 to 7.0). This layer has indefinite structure but is friable if worked properly. If worked too wet, it puddles easily, dries out hard, and breaks to irregularly shaped hard clods. The quantity of gravel is not great in this layer, but sufficient to have some effect on tillage. If the soil is not disturbed, grass roots tend to concentrate in the first 1 or 2 inches, which is slightly darker in color, but numerous roots occur throughout the surface layer.

The upper subsoil extends to depths of 15 to 30 inches; it is reddish-brown in color, finer in texture than the surface soil, and contains fewer grass roots. Worm holes, particularly in the upper part, increase its porosity. This layer is more compact than the surface soil, and the weak aggregates show some colloidal coating. The percentage of gravel is variable, and the reaction is slightly acid to neutral (pH 6.0 to 7.0).

The lower subsoil, extending to depths of 30 to 60 inches, is reddish-brown gravelly heavy clay loam. In most places this layer is slightly more reddish than the upper subsoil. It shows considerable accumulation of colloidal clay, and is fairly dense and compact but has no definite structure. It softens and crumbles easily when moist but is decidedly sticky when wet. Roots and water have some difficulty penetrating the layer.

Stratified gravelly materials gradually replace the lower subsoil as depth increases. Some of the gravel materials have very little interstitial soil material. The gravel is well-rounded and much like that under the Corning and Redding soils but usually not so coarse. Cobblestones seldom occur in this soil, whereas they are common in the Corning and Redding soils and their parent materials.

The natural cover is grass, but most of this soil is now used for dry-farmed grain or for irrigated crops, mostly fruit trees or vines.

Grain yields are fair in more favorable seasons, and are better than those from the San Joaquin, Corning, or Redding soils of the vicinity. The grapes and other fruits are superior to those from the San Joaquin and Corning soils but inferior to those from the Honcut and Hanford soils of the same general locality. Irrigation water is pumped from wells, although the soil is close enough to the American River to permit some pumping from the river during part of the growing season at least. The deposits giving rise to this soil are gold-bearing, and some of them are being dredged for placer gold. Dredging done in the past has completely destroyed areas of this soil for agricultural use.

PETERS SERIES

The soil of the Peters series occurs in small bodies. It is derived from fine-textured shalelike materials, probably rhyolite or andesite tuff. In some places a little lime is found in the layer of weathering bedrock; and even where there is no lime, this layer is slightly basic in reaction. The rest of the soil profile is neutral or slightly acid.

The surface soil, extending to depths of 6 to 20 inches, is very dark-gray or dark grayish-brown fine-textured material, usually of adobe structure. The quantity of organic matter is moderate, and the reaction is slightly acid to neutral (pH 6.0 to 7.0). The immediate surface often sloughs off and crumbles, giving a flaky appearance. The larger shrinkage cracks extend down into the upper subsoil, which breaks out in large blocks.

The upper subsoil is dark gray or dark grayish brown, slightly acid in reaction, and contains many roots. The lower subsoil is lighter in color and nearly neutral in reaction. It contains fewer roots and many rock fragments.

The parent material, which begins at depths of 24 to 48 inches, consists of fine-grained, light-gray materials showing variable degrees of consolidation. The upper weathered zone is soft and crumbles into many shalelike fragments, usually basic in reaction and occasionally slightly calcareous. The deeper unweathered parent material is stratified, shalelike, and varies considerably in fineness and degree of consolidation. None of the material is extremely hard, and the bedding planes are approximately horizontal.

This soil is closely associated with the soils of the Pentz series, which it resembles in degree of profile development, mode of formation, and use. It developed from similar rhyolite and andesite tuff materials but is much finer textured than the Pentz soils. It is used only for range pasture. The forage produced is good but not so abundant as that of the Pentz soils. It has, however, a higher proportion of burclover and is grazed more closely than soils of the Pentz series.

Peters clay (adobe), rolling and hilly (8–25 percent slopes) (Pk).—This soil occurs in small scattered bodies associated with the Pentz and Redding soils. The surface soil, to depths of 6 to 18 inches, is dark-gray or dark grayish-brown clay of well-defined adobe structure and slightly acid to neutral reaction (pH 6.0 to 6.7). Large shrinkage cracks form during dry periods and extend downward into the subsoil. The surface few inches breaks by secondary cracking into small, firm, angular aggregates. The lower part is blocky and has cracks that make it appear prismatic in structure. Rounded gravel may occur on the surface and throughout the upper layer; this gravel represents

remnants of Redding soil material, which in places caps the formation that gives rise to the Peters soils.

The subsoil is slightly acid or neutral dark-gray or dark grayish-brown clay that shades to olive gray and has many rust-brown iron mottlings in the lower part. At depths of 24 to 48 inches this clay is replaced by well-weathered, soft, crumbly olive-gray to light-gray bedrock, generally mottled with iron stains. The upper part of the bedrock is neutral or slightly basic, and in some places contains a small quantity of lime; the deeper part is loosely consolidated, light-gray, stratified, shalelike material.

Erosion of this soil is negligible or only slight. The adobe structure and high water-holding capacity apparently are effective in preventing erosion even where the soil is intensively grazed. The soil is used only for range pasture.

PLACER DIGGINGS

Placer diggings (PL) consist of areas that have been worked over and disturbed by placer gold mining, most of which was done with pick and shovel at an earlier period. The chief soils affected were Honcut gravelly loams and Redding, Corning, Auburn, Whiterock, and Dorado soils. Placer diggings occur most frequently in the Redding soils, where they occur as small mounds 1 or 2 feet high and 3 to 6 feet across the base. The depth of soil disturbance is usually less than 2 or 3 feet. Diggings in the residual soils usually followed quartz vein outcrops. Small contour ditches carried water from creeks or reservoirs to practically all placer mining areas. These ditches often broke, causing considerable gullying in some places, but most of this gullying has been stabilized naturally, so that placer mining is now the source of little active gullying. Practically all areas are used for range pasture. They support only very sparse grass, and are so loose and rough that livestock have difficulty in getting over them.

REDDING SERIES

The extensive soils of the Redding series are developed on gravelly and cobbly old valley-filling materials. They occupy undulating and rolling terracelike positions along the eastern edge of the valley and range from shallow to 40 feet or more deep. The hard well-rounded gravel consists mainly of quartz, quartzite, and andesite rocks but includes smaller quantities of slate, sandstone, and granitic and basic igneous rocks.

The surface soils are reddish brown or light reddish brown and have a granular structure. Gravelly or cobbly and medium-textured, they break when cultivated into irregularly shaped clods that are slightly hard when dry and slightly sticky when wet.

The upper subsoils are composed of reddish-brown materials that have a slightly finer texture and redder color than the surface soils. The gravel is extremely variable in quantity and size. The soil materials have a block structure in place but are porous. The lower parts of the upper subsoil may be slightly mottled with rust-brown iron stains caused by water standing above the lower subsoil, which is very heavy and much less pervious. The lower subsoil occurs abruptly at depths of 10 to 30 inches; it consists of gravelly red or reddish-brown clay. This clay is highly colloidal, and very plastic or very sticky when wet. With increased depth the subsoil becomes

more grayish or brownish in color and has more manganese stains. This more grayish or brownish part ranges in thickness from ½ inch to about 10 inches. The grayish color is probably the result of water remaining for some time just above the relatively impervious hardpan substratum.

The hardpan substratum appears to have become indurated or hardened by the precipitation of cementing siliceous compounds. The immediate surface of the hardpan material is often considerably harder than the lower parts and is much stained by manganese. In some places the hardpan layer is consolidated to a depth of only 1 or 2 feet; in other places it may be strongly consolidated to depths of 15 or 20 feet.

The parent materials are very much like those of the Perkins and Corning soils but are found on higher terraces. The gravelly and cobbly deposits are underlain for the most part by softly consolidated sandstone and shale formations, although along the eastern edge of the area they may be underlain by andesites, amphibolite schist, granodiorite, or Jurassic slates.

Redding soils are undulating or rolling, with broad swales and a hummocky microrelief. The hardpan or substratum does not conform to the microrelief of the surface relief. The upper subsoil layer does appear to conform more closely to minor differences in surface relief; it is thicker under the mounds than in the depressions, whereas the other horizons may not differ greatly.

On the broad more nearly level terrace tops, there are small shallow basinlike areas where the soil is darker and finer textured and very similar to the Alamo soil. These areas, seldom as large as 1 acre, are too small and few to warrant separation.

Under natural conditions, the Redding soils are grass-covered (fig. 2). The original cover is thought to have been dominantly needlegrass and some ryegrass. The present cover is mainly ryegrass, bromegrass, or wild oats. The soils are used mainly for range pasture, but the forage is only fair. The yields from dry-farmed wheat and barley are relatively low. A few plantings of grapes and olives have been abandoned. Because the yields of most crops are low and irrigation water is not available, many farmsites have been abandoned. Recently many small check dams have been built to hold back storm waters for livestock. These small reservoirs cover areas from less than 1 acre to 5 or 10 acres. They are inexpensive to build and furnish water for livestock during winter, spring, and early summer, after which the stock is moved into the Sierra Nevada.

The materials from which the Redding soils have formed are gold bearing, and large areas have been worked over by placer, hydraulic, and dredging operations (fig. 3). Dredging is still in progress, and in time much of the area occupied by these soils probably will be dredged for gold, as large tracts are now held under option for this purpose.

Redding gravelly loam, undulating and rolling (2–15 percent slopes) (Rb).—This extensive soil occupies high terraces along the eastern edge of the Sacramento Valley. The surface soil is 5 to 15 inches of strongly to medium acid (pH 5.0 to 6.0) reddish-brown or light reddish-brown gravelly loam. It puddles easily when wet and is slightly hard when dry. On the surface and throughout the soil

FIGURE 2.—Beef cattle on Redding gravelly loam, undulating and rolling.

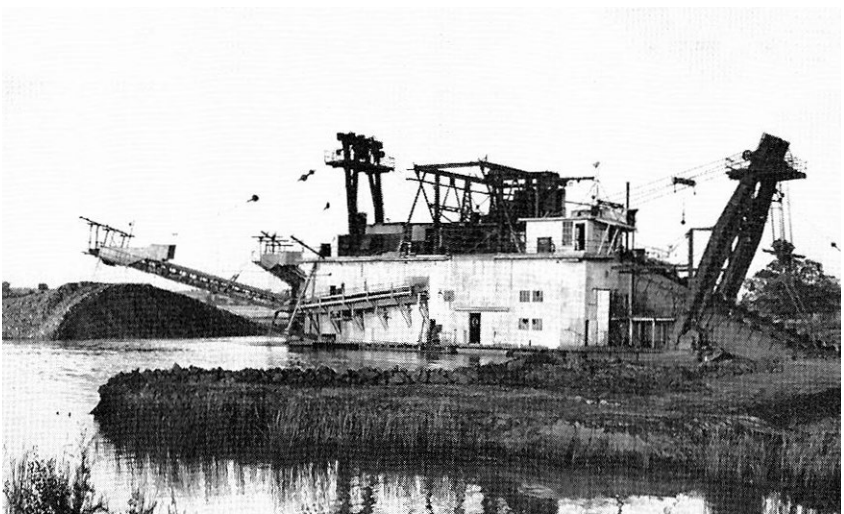

FIGURE 3.—Redding and related soils are extensively mined for gold by large dredgers which leave only fields of gravel heaps (Tailings) that permanently ruin the land for agriculture.

there is a considerable quantity of well-rounded gravel—mostly quartz, quartzite, and andesite—and smaller quantities of other rocks. Numerous grass roots occur throughout, but tend to concentrate in the top 1 or 2 inches. This root concentration causes the immediate surface to be slightly darker and have a higher organic-matter content. This topmost part is also often slightly less acid.

The upper subsoil, extending to depths of 15 to 30 inches, is reddish-brown gravelly clay loam or gravelly heavy loam. This porous layer has many insect and worm holes and breaks to a weak blocky structure when disturbed. Some of the soil aggregates and the surfaces of insect holes have a thin colloidal glaze. The reaction (pH 5.5 to 6.5) is not so strongly acid as that of the surface soil.

The lower subsoil, which extends to depths of 20 to 36 inches, is reddish-brown or red gravelly clay, which is very sticky when wet. When dry, it is extremely hard, and cracks to a poorly defined prismatic structure. A few small iron pellets about the size of buckshot occur in the lower subsoil, but these are less numerous than in the San Joaquin, Alamo, or Glann soils. The reaction ranges from medium acid to neutral (pH 5.5 to near 7.0). The soil above hardpan is saturated for considerable periods during the rainy season and this makes the lower part of the subsoil gray. This grayer material, ranging from less than 1 to about 12 inches in thickness, contains some shotlike pellets and in places some dark shiny manganese stains.

The hardpan, encountered at depths of 20 to 40 inches, consists of semiconsolidated gravelly and cobbly material that extends many feet and that looks much like softly consolidated conglomerate. The upper layer of this substratum, 3 to 20 inches, or even several feet in thickness, is generally more firmly cemented than the lower part. The upper few inches have considerable manganese stains. The cementing material is pale brown or light brownish gray, and siliceous. Its reaction ranges from very strongly acid to neutral (pH 5.0 or less to pH 7.0 or slightly higher).

The quantity, size, and distribution of gravel vary throughout the profile, but the lower subsoil layers usually have the least and the substratum the most gravel. The parent deposits are deeper along the edge of the valley and more shallow toward the hills. The soil has somewhat hummocky microrelief, with small mounds and depressions similar to those on the San Joaquin soils. In some areas the soil is also characterized by small basins, usually much less than an acre in size, that are darker colored and finer textured than normal. These small basins remain wet much longer than surrounding areas and, except for being gravelly, resemble the Alamo soil.

The soil is normally covered by grass and associated plants and some oaks. It is used mostly for winter and spring pasture, as the stock are moved to summer range in June or early in July. Along the edge of the valley, some of this soil is dry-farmed to wheat or barley, but yields are low. Plantings of grapes and olives do not give high yields, and many have been abandoned. The few wells are not very satisfactory, because the gravelly hardpan does not allow sufficient water-bearing strata to develop. Much of the water supply for livestock is impounded in small reservoirs formed by earth dams across drainageways. These reservoirs, which may cover as much as 10 acres, collect sufficient water during the rainy months to last until the livestock is moved to summer range.

Mining of these gold-bearing parent materials has been carried on from the early days of the gold rush to the present time. It may be only a few decades until the rest of this soil is completely destroyed by dredging (see fig. 3).

Redding cobbly loam, undulating (3–8 percent slopes) (RA).—This inextensive soil occurs on high terraces as a capping on igneous rock at elevations of 400 to 600 feet. The surface soil is 6 to 12 inches of reddish-brown or light reddish-brown cobbly loam that contains many well-rounded pieces of gravel and cobblestones ranging from less than an inch to 8 inches in diameter. There are also many cobblestones on the surface. The cobblestones are mostly quartz or quartzite, though there are smaller quantities of various other igneous rock materials. The surface soil is very strongly to medium acid (pH 4.5 to 6.0).

The upper subsoil extends to depths of 15 to 24 inches; it is a reddish brown cobbly clay loam, more porous than the surface soil. It has many worm and insect channels and the structure is indistinct because of the large number of embedded cobblestones. The lower subsoil, extending to depths of 24 to 42 inches, is heavy compact cobbly clay that contains so many stones the structure is indistinct. This reddish-brown or brown lower subsoil is unlike Redding gravelly loam in that it does not have a grayer color just above the hardpan. The hardpan is somewhat less consolidated and more permeable to water than that in Redding gravelly loam. Cobblestones are very numerous and extend to variable depths.

The native cover is scattered trees, mainly oak and digger pine, and grass. The soil is too stony to be farmed and is used only for grazing.

RIVERWASH

Riverwash (Rc) usually occurs in long narrow bands along the streamways, but it also includes a few areas of gravelly outwash from hydraulic mining. Along the larger streams such as the American and Cosumnes Rivers, it occurs as sandy or gravelly bars marginal to the channel or as islands in the stream channel. It also occupies channels along some of the minor drainageways and intermittent streams. Although exposed during the dry summer season, it is overflowed and forms part of the streambed in periods of flood. This material is never farmed, but it produces a little grass, which is used for pasture. Some willows or cottonwood trees usually grow in these areas and provide shade for stock.

RYDBERG SERIES

The inextensive soil of the Rydberg series, which occurs in the narrow flood plains along small drainageways, is a recent, slightly to medium acid alluvial soil. It forms from stratified, friable layers of light-gray, very light-gray, or pale-yellow alluvium derived mainly from soils of the Amador series. Its mode of formation is similar to that for Bear Creek and Honcut soils. The series is characterized by its light-gray or light brownish-gray color, medium texture, and usually high silt content. Roots are not numerous in the underlying materials, and the reaction is slightly less acid than in the upper horizons (pH 6.0 to 7.0). The natural cover consists mainly of grasses, and the soil is used only for pasture.

Rydberg loam, very gently sloping (0–3 percent slopes) (Rd).—This inextensive soil occurs along narrow drainageways in the eastern part of the area. The surface soil is 10 to 24 inches of light-gray or light brownish-gray, friable loam, or in a few places fine sandy loam. Grass roots are plentiful throughout this layer, but they tend to concentrate in the top 1 or 2 inches, which are somewhat darker and slightly less acid (pH 6.0 to 6.5) than the rest of the surface soil (pH 5.0 to 6.0).

The subsoil consists of friable light-gray, light brownish-gray, or very light-gray loam or fine sandy loam (pH 5.0 to 6.5) that contains fewer roots than the surface soil. The underlying material is stratified very light gray, light gray, or pale-yellow sandy material that rests at depths of 20 to 80 inches on softly consolidated material of the Ione or similar geological formation.

The soil is used only for range pasture, which is somewhat better than that on the Amador soils.

SACRAMENTO SERIES

The soils of the Sacramento series occur along the flood plain of the Sacramento River. They have neutral or slightly basic surface soils, and moderately basic and intermittently calcareous subsoils. They have a youthful profile and only slight subsoil development. Their parent material is mixed alluvium deposited along the flood plain of the Sacramento River in level areas that were normally subject to annual overflow. Under natural conditions they were partly under water throughout winter and spring and always had a high water table. Reeds, tules, sedges and other water-loving plants made up the principal vegetation and have been responsible for the high organic-matter content. The texture is moderately fine. Their parent material was deposited in a manner similar to that of soils of the Columbia series, but the soils occupy a lower position, have a higher organic-matter content, and are darker in color than the Columbia soils.

The surface soils are dark-gray, fine textured, and moderately high in organic matter. The subsoils are dark-gray and highly mottled with iron stains, are slightly more compact than the surface soils, and have some colloidal staining. The mottlings are rust brown in the upper parts but they become grayer and duller with depth. The consistence is friable, and the material is easy to work and easily penetrated by roots and water. Some segregated lime occurs irregularly in the lower part in some places. The deeper materials are grayish brown, stratified, fine-textured, highly mottled with iron stains, and occasionally slightly calcareous.

The soils are extensive and are used mainly for field and truck crops, although some fruit, mostly pears, is grown along narrow strips immediately adjacent to the levee of the Sacramento River where the water table is not so high. Yields of most crops are high, and quality is good. The soils are closely related to the Columbia and Freeport soils, being slightly older than the Columbia but somewhat younger than the Freeport soils. Under natural conditions, the soils are subject to annual flooding; but, where protected by levees and drainage, they are capable of producing good yields of a wide range of field crops. Almost all of the Sacramento soils in the American Basin in the northern part of the area have been covered with soil material of the Columbia series to depths of 12 to 60 inches.

Sacramento silty clay loam, nearly level (0–1 percent slopes) (Sa).—This soil occurs in basinlike areas along the flood plain of the Sacramento River. It has an 8- to 18-inch surface layer of dark-gray friable silty clay loam, which breaks into granules. Its high organic matter content aids materially in maintaining a favorable tilth and a low volume weight. It resists puddling even when worked at unfavorable moisture content. The reaction is nearly neutral.

The subsoil between depths of 2 and 5 feet consists of dark-gray, friable silty clay loam or clay loam that is high in organic matter and mottled with many rust-brown iron stains. Although its volume weight is considerably less than that of many soils of this texture, this layer is a little more dense than the surface soil. Colloidal glazing lines some root and insect holes. Thin layers of highly organic material may occur anywhere in this layer or in the lower part of the surface horizon. The subsoil also contains thin ashlike layers from burned-over organic matter that was once a part of a former surface soil. The reaction of the subsoil is moderately basic, and it may or may not be slightly calcareous.

The underlying material consists of gray or dark-gray stratified layers, chiefly moderately fine or fine, although in places it has sandy streaks. This material is highly mottled with gray or bluish-gray iron stains. It is basic in reaction and may or may not be calcareous. Under natural conditions this part of the profile was below the water table.

Because of its moderately fine texture, the soil is slowly permeable to roots and water but it can be drained artificially. Due to its low position, it must be protected from overflow by levees and drained before it can be farmed.

Where reclaimed, this soil is suitable for a wide range of field and truck crops. Large, high-quality yields are obtained. Fruit trees generally do not do so well, although pear trees produce good yields immediately adjacent to the levees of the Sacramento River where the water table is somewhat lower than average.

Alfalfa, beans, tomatoes, and asparagus are important field and truck crops. Alfalfa yields are heavy, but the stands normally do not live more than 4 years. Tomato yields are particularly good. The yield may be as much as 25 tons of canning tomatoes an acre, although the average is somewhere between 14 and 18 tons. Asparagus stands last 7 to 10 years and produce high yields, but are subject to wireworm infestation, which may ruin the crop if not controlled. No fertilizer is used on alfalfa or asparagus, and little if any on beans. The application of 1 to 3 pounds of nitrogen per year to each pear tree gives good results. Fertilizers are usually applied to miscellaneous truck crops for fresh market, but seldom for canning crops such as tomatoes and spinach.

Sacramento silty clay loam, overflowed, nearly level (0–1 percent slopes) (Sb).—This soil, in the southern part of the area, consists of areas subject to overflow and not fully protected by levees. Overflow hazard reduces the number of suitable crops and prevents as intensive use as for protected areas.

SAN JOAQUIN SERIES

The San Joaquin soils, which are the most extensive in this area, occupy the gently undulating plain from the valley trough eastward

FIGURE 4.—Profile of San Joaquin soil showing hardpan (just below hand pick) and underlying partially consolidated substratum.

to the higher terraces occupied by the Corning and Redding soils on the eastern fringe of the Sacramento Valley. They are traversed and entrenched by the American and Cosumnes Rivers and by some of the larger creeks, such as Linda, Arcade, Laguna, and Dry Creeks. The surface of these soils slopes gently to the west at a gradient of something less than 1 percent, but the microrelief is hummocky and uneven, with ill-defined hogwallows and numerous drainage channels. The San Joaquin soils have strongly developed profiles, with clay subsoils that rest on indurated hardpan layers ranging from very thin plates to 6 or 8 inches, and are underlain by partially consolidated materials. These soils have developed on transported mixed rock deposits on the valley floor. Most of these materials probably were derived from granite and some volcanic and metamphorized sedimentary rock sources.

The surface soils are light brown or reddish brown. When moist, they have a more pronounced reddish color and are soft, but they dry out moderately hard and have a baked surface. They have no definite structure in place but when disturbed break into irregularly shaped somewhat brittle fragments, which are not difficult to crumble. The upper subsoils consists of reddish-brown material that is slightly lighter than the surface soils and usually of somewhat finer texture. The lower part of this layer, just above the underlying heavy clay, may be somewhat mottled, have some shiny manganese stains, and in places have a few iron pellets about the size of buckshot. These pellets are a result of an intermittent perched water table above the much less pervious deeper materials.

The lower subsoil is composed of reddish-brown or brown clay, which is very plastic when wet and hard when dry. When wet this layer swells and becomes impervious. Manganese stains and many iron pellets are common in this layer, particularly near the trough of the valley. The lower part just above the indurated hardpan may be of duller color and even gray in places. The lower subsoil is neutral or slightly basic in reaction, and may contain small quantities of segregated lime just above the hardpan.

The hardpan occurs at 10 to 40 inches but the average is 2 feet (fig. 4). The hard indurated layers are high in manganese and in places contain some lime. They are cemented by materials leached from the soil profile and precipitated on the top of an underlying somewhat consolidated substratum and in cracks near its surface. The underlying substratum, occurring in horizontal beds, ranges from sand to finer textured materials varying in cementation or hardness. The upper parts are pale brown or light brownish gray, but deeper layers are usually very light gray.

Without irrigation these soils are fair for range pasture and produce fair yields of dry-farmed grain in more favorable seasons. Yields in excessively wet years, however, are often as low as in very dry years because the impervious hardpan causes water to stand in small ponds over the field and retard the growth of the grain. Under irrigation, a wide variety of crops are grown. Most of the strawberries raised in the area are grown on these soils. The yields are 800 to 1,000 12-quart crates an acre. Tokay grapes are grown extensively, and yield an average of about 4 tons an acre. Yields of grapes on the Hanford soils on the Mokelumne River fan in the Lodi district immediately to the south, in San Joaquin County, are two or three times greater.

Various fruit trees are grown but give low yields, and many of the orchards are being abandoned.

Among the field crops, Ladino clover appears to be well adapted to the San Joaquin soil; the yields are good, and the acreage is rapidly increasing. Alfalfa yields are not good, and stands are short-lived. Truck crops, such as cabbage, cauliflower, lettuce, and canning tomatoes, are planted on increasing acreages in the vicinity of Perkins and Elk Grove. The yields, although not so high as on the more recent alluvial soils of the area, are fairly good. Most of these soils occur in areas where irrigation water must be pumped from wells. The quality of water is good, and so far no shortage of water appears imminent. Nevertheless, if the entire area of these soils were farmed to Ladino clover or similar crops requiring larger quantities of water, the water table would drop considerably within a few years.

These soils are closely associated with the Glann soil, and also with the Alamo, which are dark-gray, fine-textured soils that occur in low spots among bodies of San Joaquin soils. The Glann soil occupies the lower fringes of the valley plain and has developed under the influence of a high water table.

A number of areas of San Joaquin soils occur where the hardpan is at a depth greater than 5 feet. Such areas are mapped as deep phases, and in many localities they are similar to soils of the Placentia series of the Auburn Area (*6*) and the Ramona series of the Lodi Area (*7*). Road cuts and other exposures show considerable variation in depth to the underlying formation.

San Joaquin sandy loam, very gently undulating (0–3 percent slopes) (Sk) —The surface soil is 4 to 12 inches of light-brown or reddish-brown medium acid sandy loam (pH 5.5 to 6.0 or slightly higher). This material has a strong tendency to become puddled if worked or pastured when too wet, and plowsoles develop easily. When dry it is moderately hard and breaks to a cloddy condition when disturbed. This layer contains numerous fine roots, but under grass cover the grass roots tend to concentrate in the top 1 or 2 inches. This concentration of roots gives the topmost part of the surface a slightly darker color, a higher organic-matter content, and a slightly higher pH.

The upper subsoil extends to depths of 15 to 30 inches; it is a reddish-brown porous loam with many worm and insect openings. This layer is friable when moist but somewhat brittle when dry. Some of the soil aggregates and the lining of some of the worm holes have colloidal stains. There may be a little rust-brown mottling and small buckshotlike iron pellets in the lower part of this layer, but these are not so numerous as in the lower subsoil. The layer is slightly less acid than the surface soil.

The lower subsoil consists of brown or reddish-brown compact clay that contains few roots. This material is very sticky when wet, extremely firm when moist, and very hard when dry. When dry, the aggregates are prismatic or cubical and have heavy colloidal coatings. The lower subsoil becomes duller with depth and may be olive gray just above the hardpan or impervious substratum. Many buckshotlike iron pellets occur in this layer. The reaction is neutral or slightly basic, and in places there may be a very small quantity of lime just above the hardpan.

The hardpan in this soil occurs at depths ranging from 18 to 48 inches, but it is usually at 24 or 30 inches. It consists of a somewhat

consolidated formation of old water-laid sediments, the upper part of which is usually indurated and somewhat laminated. There are a number of manganese stains throughout the upper part, and some lime in seams or cracks. The lower part is stratified and is consolidated to varying degrees.

The general relief of this soil is fairly smooth, but the microrelief is mildly hummocky. The mounds are not so regular as in some of the soils of the San Joaquin series mapped elsewhere.

This soil is closely associated with San Joaquin sandy loam, undulating, and other soils of the San Joaquin series. It is used mostly for dry-farmed grain, but some table and wine grapes, tree fruits, and strawberries are grown. The yields of most of these crops are not very good, but strawberry yields are satisfactory. Yields of dry-farmed wheat and barley are fair. Grapes yield about 4 tons an acre, which is much lower than yields on the more recent Honcut or Hanford soils in the area. Tree fruits yield a little more than half as much as they do on the more recent alluvial soils. Strawberries yield 80 to 1,000 12-quart crates an acre.

Irrigation water is obtained from deep wells. The quality of water is good. Under present use the supply seems adequate, but the ground water supply is probably not sufficient to bring much more than 20 to 40 percent of this soil under irrigation.

San Joaquin sandy loam, undulating (3–8 percent slopes) (Sh).—This soil occurs on gentle slopes cut by many small drainageways. The profile is essentially the same as that of San Joaquin sandy loam, very gently undulating.

The old valley plain this soil occupies is crossed by numerous small entrenched drainageways that increase the unevenness of the relief. The microrelief is somewhat hummocky and characterized by many small mounds that rise 12 to 20 inches above the adjacent depressions. These mounds are neither so regular nor so well-developed as those of San Joaquin soils farther south, as they have a distinct hogwallow microrelief.

The surface soil ranges from 4 to 14 inches deep and averages about 6 inches. It is a light-brown or reddish-brown strongly to medium acid sandy loam (pH 5.0 to 6.0) that contains many fine roots, puddles easily, and dries out moderately hard.

The upper subsoil extends to depths of 12 to 30 inches; it is a reddish-brown loam or light clay loam that contains more pores than the surface soil but fewer roots. It may be slightly mottled with rust-brown iron stains and have some buckshotlike iron pellets in the lower part. The pH, which is slightly higher than for the surface soil, increases somewhat with depth. The deeper subsoil is reddish-brown or brown, compact clay. This material has a prismatic or cubical structure when dry, and the aggregates are heavily coated with colloidal stainings. Many small buckshotlike iron pellets occur in this layer. The color becomes increasingly more grayish with depth; and, in some places immediately above the impervious hardpan, it is olive gray. The reaction is neutral or slightly basic, and a little segregated lime may occur as thin seams just above the hardpan.

The hardpan may be 15 to 42 inches below the surface but is usually between 20 and 24 inches. This material is harder in the upper part than below, and is inclined to be platy. Manganese stains occur along

seams and cracks, and some lime may be present. The lower part of the hardpan is stratified, softly consolidated material very similar to the parent material of the Whitney or Pentz soils.

The soil is used mainly for dry-farmed grain and poultry raising. Most of the poultry feed is grown elsewhere, although some local grain is used in ready-mixed feeds, and many poultry farms have small acreages of Ladino clover adjoining their poultry houses. North of North Sacramento large areas of this soil are divided up into ½- to 3-acre tracts, which people employed in Sacramento use for homesites and for small family gardens, a few fruit trees, some poultry, and occasionally a cow. Under these conditions yields are variable but usually fairly low, because the farms are not operated as efficiently as commercial farms or poultry plants. The grain yields are similar to those obtained on San Joaquin sandy loam, very gently undulating. Erosion of this soil is slight, except for a few places where some gullying occurs near drainageways.

San Joaquin sandy loam, deep, undulating (3–8 percent slopes) (Sg).—This soil is characterized by greater depth to the hardpan, which is always below 5 feet. It is not so extensive as some others of the San Joaquin series, yet it occurs in a number of fairly large bodies. Erosion is not very pronounced, although some damage has been caused by gully erosion in a few places along drainageways. This soil has less hummocky relief than that typical of San Joaquin soils.

The surface soil, 6 to 15 inches deep, is light-brown or reddish-brown slightly or medium acid sandy loam or gritty sandy loam. It puddles easily and bakes hard on drying. Plowsoles develop readily if it is worked at an unfavorable moisture content. Many fine roots extend throughout this layer, but in grassy areas they tend to concentrate in the upper 1 or 2 inches and give this part of the surface soil a somewhat darker color.

The upper subsoil, extending to depths of 15 to 30 inches, is a reddish-brown porous loam or clay loam slightly redder than the surface soil. Worm and insect holes, some lined with colloidal glazing, are common. When moist, this material is friable, but it dries out moderately hard and brittle. The lower part may have some small buckshotlike iron pellets and some rust-brown iron mottlings. It is usually a little less acid than the surface soil. The lower subsoil is reddish-brown or red moderately compact sandy clay or clay. This material dries hard and when disturbed breaks into irregularly shaped angular blocks that are well-glazed with colloidal stainings. The layer does not have many roots, but it is more pervious to roots and water than the lower subsoils of the other San Joaquin soils in the area.

The substratum consists of reddish-brown or red sandy clay loam or sandy clay. It contains considerable grit and in places moderately large quantities of mica. A few roots extend down into this material, which is slightly compact but less so than the layer above.

This soil is planted mainly to dry-farmed grain, although some fields are in Ladino clover. Grain yields are slightly higher than those on other San Joaquin soils. Clover yields are about the same as on San Joaquin loam.

San Joaquin loam, very gently undulating (0–3 percent slopes) (Sf).—This soil, the most extensive in this area, occurs on broad

relatively smooth valley plains south of the American River and extends beyond the southern boundary of the survey area. It is crossed in a southwesterly direction by the Cosumnes River and in a generally westerly direction by such minor streams as Laguna and Dry Creeks. The slope of this valley plain is toward the west, with a very gentle gradient of a few feet per mile. The microrelief is somewhat hummocky, with small mounds about a foot higher than the adjacent depressions. To the east the soil extends to the gravelly and somewhat higher terraces occupied by soils of the Corning and Redding series; but, along Laguna Creek in the southern part of the area, it occupies lower terraces slightly above the present flood plain.

The surface soil, 5 to 12 inches deep, is strongly to medium acid (pH 5.0 to 6.0) brown or reddish-brown loam. It is friable when moist but it dries to a moderately hard blocky structure. It puddles easily and develops plowsoles readily when worked at an unfavorable moisture content. Many roots extend through this layer, but under grass cover they tend to concentrate in the top 2 inches and give a slightly darker color to that part.

The upper subsoil occurs between depths of 15 and 30 inches. It is a porous, reddish-brown loam or light clay loam that contains some fine roots and a number of worm and insect holes, most of which are glazed with colloidal coatings. There are not so many roots as in the surface soil, and the number decreases with depth. The lower part of this layer is somewhat mottled with rust-brown iron stains and contains some buckshotlike pellets. The material in this layer is friable when moist, but when dry it is brittle and breaks into somewhat angular blocks if disturbed. The reaction is not so acid as that of the surface soil.

The lower subsoil is brown or grayish-brown compact heavy clay loam or clay, sticky when wet, very firm when moist, and hard when dry. It is somewhat prismatic or blocky, and the aggregates are heavily coated with colloidal glazing. Roots are few in this layer. Small buckshotlike iron pellets are particularly numerous in this layer in areas where the lower edge of the valley plain joins the valley trough. In some places the lower part of this layer is olive gray and contains some gray or bluish-gray iron stains. The reaction is neutral or slightly basic, and in some places a small quantity of lime occurs just above the hardpan.

The hardpan occurs at depths of 15 to 42 inches. It consists of a hard, somewhat platy, crustlike, cemented deposit on stratified layers of semiconsolidated shaly or sandstonelike material, which varies in degree of consolidation and extends to considerable depths. The upper material is somewhat platy, has considerable manganese stains, and in places has segregated lime along the seams and cracks. The crust-like upper part of this layer may be only a fraction of an inch in thickness but is usually 3 to 8 inches.

Along Laguna Creek this soil has a more yellowish color throughout the profile than is typical for the series, but in other respects it is essentially the same. Some slight variation in parent material may account for the differences in color. One or two small areas just south of Sacramento have much more lime in the lower subsoil than is typical. This condition, however, is local and does not alter farming practices or yields in any way. This soil is associated with other soils of its own series and with the Alamo soil, which is dark-colored

and fine-textured and occupies low-lying spots surrounded by areas of San Joaquin soil.

This soil is most extensively used for pasture and dry-farmed grain, but some areas reaching from Sacramento southward to slightly beyond Elk Grove are under intensive irrigation. Fruit trees, grapes, and strawberries, and some Ladino clover are grown in this area.

Most of the grapes, chiefly Tokay, are sold for table use, and the end of the crop is bought by the wineries. Average yields are low compared with those from the same variety of grapes on the Honcut soils in the same locality or on the Hanford soils of the Mokelumne River fan near Lodi in San Joaquin County, but the quality is good. Strawberries are grown almost exclusively on this and other soils of this series; normal yields are 800 to 1,000 12-quart crates per acre. Ladino clover also produces heavy yields on this soil. A considerable acreage at Perkins, near Sacramento, is planted to truck crops, which yield fairly well but not so well as on the Honcut and Hanford soils of the same locality.

All of the water used for irrigating this soil is pumped from wells. The quality is good, but the supply is relatively limited. The hardpan is not always porous, and the ground-water reservoir is not capable of supplying water to much more than 20 to 40 percent of this soil. Under the present cropping system, there is no shortage of water, but an expansion of the acreage of Ladino clover, particularly north of the Cosumnes River, may bring about a decided lowering of the water table in the area. Considerable leveling must be done in preparing this soil for irrigated agriculture.

San Joaquin loam, undulating (3–8 percent slopes) (SE).—This usually occurs along the edges of drainageways in association with San Joaquin loam, very gently undulating. The areas are irregularly shaped, usually long and narrow. The profile is essentially the same as that of San Joaquin loam, very gently undulating, as this phase differs from it only in slope.

This soil is used mostly for dry-farmed grain or pasture and yields about the same as San Joaquin loam, very gently undulating. Because of its undulating relief, it is not used to any extent for irrigated agriculture.

San Joaquin loam, deep, undulating (3–8 percent slopes) (SD).—This soil occurs usually in small- to medium-sized bodies, though a few large areas are found south of the Cosumnes River in association with other soils of the San Joaquin series. This soil has a less pronounced hummocky microrelief than most San Joaquin soils. It is characterized by the depth to the hardpan, which is always below 5 feet. Softer unconsolidated material takes the place of the hardpan in some localities.

The surface soil is 6 to 16 inches of brown or reddish-brown loam that puddles easily and dries moderately hard. There are many fine roots throughout this layer. It is medium to slightly acid (pH 5.5 to 6.5).

The upper subsoil is reddish-brown or light reddish-brown clay loam. Many worm and insect openings increase porosity, but roots are not as numerous as in the surface soil. The lower part may have a few buckshotlike iron pellets and occasionally some rust-brown iron stains. The lower subsoil, encountered at depths of 20 to 36 inches,

is brown or reddish-brown moderately compact clay or sandy clay. Some buckshotlike iron pellets occur, but usually not so many as in the lower subsoil of the other San Joaquin loam or sandy loam soils. When dry, this material breaks into hard blocky aggregates coated with colloidal stains. It is not so impervious as the corresponding material in the other San Joaquin soils.

At depths of 30 to 48 inches, the lower subsoil grades into a light reddish-brown friable sandy clay loam or clay loam substratum. This material is neither consolidated nor very compact.

Because of its greater depth, this soil is better for general crop production than most other San Joaquin soils. It is used for dry-farmed grain, or under irrigation, for a fairly wide variety of crops. Tree fruits, alfalfa, grapes, strawberries, and Ladino clover are grown to some extent. All except the strawberries and Ladino clover yield better than on the shallower San Joaquin loam or San Joaquin sandy loam. Alfalfa does fairly well on this soil, whereas it is seldom planted on more shallow San Joaquin soils.

San Joaquin loam-Alamo clay (adobe), very gently undulating (0–3 percent slopes) (Sc).—This inextensive complex occurs in association with larger areas of San Joaquin and of Alamo soils, mostly near the lower edge of the valley plain where the general relief is more nearly level. It consists of small mounds of brown or reddish-brown loam characteristic of San Joaquin loam, very gently undulating, with intervening shallow depressions or flats of dark grayish-brown clay fairly typical of Alamo clay (adobe), nearly level. The two soils are so intimately associated that they could not be mapped separately. The San Joaquin loam areas tend to be more grayish in color along the lower fringe of the mounds near the Alamo material, although the sequence of horizons is typical of the San Joaquin soil.

The San Joaquin loam of this complex has a brown or reddish-brown loam surface soil; a porous, slightly redder clay loam upper subsoil; and a grayish-brown, compact clay lower subsoil. The lower subsoil is somewhat more gray than is typical of the San Joaquin soils, and it rests abruptly on a hardpan substratum. A number of buckshotlike pellets are in the lower part of the upper subsoil and throughout the lower subsoil.

The surface soil of the Alamo clay (adobe) is dark grayish-brown clay, and the subsoil is a compact, grayish-brown clay that becomes a little lighter in color with depth. Many buckshotlike pellets occur throughout the subsoil, which rests abruptly on the hardpan. Lime occurs frequently in the lower subsoil and in the upper part of the hardpan.

This complex is used mostly for dry-farmed grain and pasture. Grain yields are very spotty. In seasons of comparative drought, the better grain grows on the lower lying Alamo soil; whereas when the rains are heavy or late in spring, the grain on the Alamo soil is either drowned out or its growth is greatly retarded.

SCABLAND

Scabland (SL) occurs along the northern and eastern parts of the area in tongue-shaped bodies consisting of very stony basaltic or andesitic lava or mudflow material. Loose and somewhat rounded rocks, usually stained nearly black where exposed to the sun, cover

the surface. The soil material between the stones is very shallow, seldom more than 1 foot thick above the more solid rock material. The surface is so rough that in many places it is difficult for livestock to walk over it. Some grass grows and provides meager pasture.

SISKIYOU SERIES

The soils of the Siskiyou series have developed in place from granitic rocks. They are stony, and moderately shallow, with numerous rock outcrops. They have weak profile development and only a slight difference in color between the surface and subsoil material. In general, the soils are grayish-brown, becoming slightly lighter in color and coarser in texture to depths of 6 to 20 inches, where they grade into a zone of decomposing granitic bedrock. This weathered bedrock often extends to considerable depth and is relatively easily penetrated by tree roots. Slopes are generally 8 to 25 percent, but along the American River Canyon they are even steeper.

These soils are normally covered by brush or scrub oak and digger pine. Because of their brushy cover, the soils do not have a heavy mat of grass in virgin areas. The grasses and shrubs, nevertheless, produce fair pasture for cattle. The soils are used for range pasture and to some extent for tree fruits, mainly mixed orchards of pears, peaches, and plums. Under orchard culture, they erode severely. Yields are low, and many of the trees are poorly developed.

The Siskiyou soils are very closely associated with the soil of the Holland series, and in the northeastern part of the area on both sides of the American River, with soils of the Auburn series. They closely resemble the soils of the Holland series, which are derived from the same type of parent material but are slightly deeper, browner, and more developed.

Siskiyou-Holland sandy loams, rolling and hilly (8–25 percent slopes) (Sm).—This complex consists of bodies of Siskiyou and Holland sandy loams so closely associated that they cannot be mapped separately.

The surface soil of the Siskiyou member is 6 to 20 inches of grayish-brown, weakly granular, micaceous sandy loam that contains considerable gritty quartz and feldspar material. The immediate surface is slightly darker in color and under natural conditions is covered with a small accumulation of surface litter from brush or trees. The color becomes lighter with depth, but the subsoil material is not well defined. The parent material consists of soft, crumbling, weathered granitic rock that extends many feet before the relatively unaltered granitic rock is encountered. This disintegrated and partially decomposed layer is penetrated by water and by a few large roots.

The Holland member of the complex is like the Holland sandy loam, rolling and hilly, described on page 42.

Because of numerous boulders and some rounded outcrops of granitic bedrock, this complex is used chiefly for range pasture. The native vegetation consists of scattered oaks and grass. The trees are smaller than those in the valley areas, but larger than trees on the Whiterock soils. Forage is fair for cattle in spring and early in summer. A few areas north of the American River in the northeastern part of the area are used for orchards. Fruit yields are low, but quality is fairly good. Tree growth is spotty, however, and some orchards have been abandoned.

Under natural conditions the porous soils absorb moisture rapidly and the vegetation prevents excessive erosion. Where the land is cultivated, however, erosion is more severe. Orchards that are clean cultivated are considerably damaged by erosion, which is not entirely checked by a cover of green-manure crops or weeds.

Siskiyou-Holland sandy loams, stony and steep (25+ percent slopes) (Sn).—This complex occurs on steep, stony slopes that have numerous granitic rock outcrops. The material between the rocks is Siskiyou and Holland sandy loams, extremely variable in thickness. Usually the layer of decomposing bedrock is much thinner and the number of rock outcrops much greater than for Siskiyou-Holland sandy loams, rolling and hilly. The plant cover is grass, brush, and a few scrub oak. Most of these areas are used exclusively for pasture.

SLICKENS

Slickens (So) is mapped where mud-laden waters from dredging and hydraulic mining have accumulated and deposited the fine material they have carried. It occurs in small depressions and along some of the flats on the upper flood plain of the Consumnes River. It is mostly reddish-brown clay, which has been separated from Redding, Corning, or Perkins soil materials by agitation over the riffle boards of dredgers and discharged into settling ponds or basins. This clay is very fine textured and often remains in suspension until the water evaporates. When dry it shrinks and cracks deeply, then slakes down to relatively flaky aggregates.

Slickens deposits are not extensive but in a number of localities cover Redding, Bear Creek, Hanford, and Honcut soil materials. Where deposited over Hanford or Honcut soils, these deposits do not greatly decrease crop yields. Where deposited over Redding or Bear Creek soils, they are generally used for pasture and are somewhat superior to the original for grass or grain. When washed onto orchard areas, however, they greatly damage the trees if the deposit reaches 6 to 8 inches in thickness.

TAILINGS

Tailings (Ta) consists of areas completely destroyed either by dredging or hydraulic mining for placer gold. It has no value for crops or grazing. Dredging, which is still going on (see fig. 3) is of comparatively recent origin. The hydraulic mining has not been carried on since it was prohibited by law. The dredgers excavate soil material, pass it over the gold recovery apparatus, and discharge the gravel and cobbles in uneven mounds and heaps, leaving in some places deep intervening pits. Hydraulic operations washed the soil material and gravel from its position by means of powerful jets of water, leaving behind large rocks.

TERRACE BREAKS, REDDING-CORNING SOIL MATERIALS, STEEP

Terrace breaks, Redding-Corning soil materials, steep (25+ percent slopes) (Tb) consists of areas of Redding and Corning soil materials along short, steep terrace escarpments.

The escarpments are covered by grass and scattered oak trees, and are used only for pasture. They produce forage about equal to that on Redding gravelly loam. Under natural conditions, these areas are not very erosive, but where the surface has been disturbed by placer mining or overgrazing, a few gullies have developed.

WHITEROCK SERIES

The soils of the Whiterock series are derived from Jurassic slate and occur along the eastern border of the valley. The slate is thin-bedded, dark-colored brittle material, with nearly vertical cleavage planes that extend in a northwest-southeast direction. The soils are very shallow, ranging from 5 to 10, or in places 15, inches in depth. They are light brownish gray or pale brown, have no profile development, and seldom have more than one soil horizon.

Erosion is not excessive. In places, the natural cover consists entirely of grass, but elsewhere there are some trees, mostly scrub oaks. These soils are similar to those of the Dorado series but much less red. They are associated with soils of the Auburn, Amador, and Pentz series. Pasture is the principal use, but wood is cut for fuel from tree-covered areas. Gold-bearing quartz veins occur, and many areas have been disturbed by mining operations.

Whiterock stony loam, rolling and hilly (8–25 percent slopes) (WA).—This soil occurs in narrow bands along the eastern foothills roughly parallel to the axis of the Sacramento Valley. Long lines of jagged bedrock outcrop are frequent. The soil, to depths of 4 to 15 inches, is light brownish-gray or pale-brown stony loam. Fragments of hard, platy, gray slate occur on the surface and throughout the soil. The rock fragments increase with depth and are generally more concentrated just above the bedrock.

The topmost one-half inch of soil is much darker, and slightly higher in organic matter content than the rest of the profile. This layer is usually only slightly acid (above pH 6.0), whereas the rest of the soil is strongly to medium acid (pH 5.0 to 6.0). Bedrock of thin, slablike, gray slate occurs at an average depth of 10 inches.

The vegetation may be annual grasses and associated plants or scrub oak with a grass undercover. This soil is in scanty range pasture. Some wood is cut for fuel.

Whiterock stony loam, steep (25+ percent slopes) (WB).—This soil has steep slopes and rough relief. It is very shallow, and rock outcrops are more numerous than in Whiterock stony loam, rolling and hilly. The surface soil, a light brownish-gray or pale-brown stony loam, rests abruptly on shattered but hard gray slate at depths normally less than 10 inches.

Some areas are entirely grass covered, but others have scrub oaks and only a thin undercover of grass. This soil is used entirely for pasture. The growth is scanty, but may be a little better than that on Dorado stony silt loam.

WHITNEY SERIES

The soils of the Whitney series normally occupy gently rolling and hilly areas in the northeastern part of the area and are developed on softly consolidated sedimentary rocks that are probably more recent than the Ione formation. The surface soils are medium-textured grayish-brown or light brown, and in places nearly reddish brown. The subsoils, much like the surface soils, may rest directly on soft sandstonelike material at a depth of 25 to 40 inches, or the surface soils may be underlain by a layer of reddish-brown clay ranging from less than an inch to more than a foot thick. This clay layer is more likely to occur near the edge of the valley, and in places the soil pro-

files greatly resemble those of the adjoining San Joaquin series. The clay layers were probably formed from clay layers in the bedrock rather than by clay formation and accumulation during weathering. The parent material, stratified softly consolidated sandstonelike beds, is grayish-brown or pale-brown, but where very softly consolidated has a somewhat reddish cast and a sandy clay texture. It is very much like the parent material of the Pentz soils but is browner or redder, possibly due to a little higher content of oxidized iron compounds.

Erosion is usually slight under the natural cover of grass and oaks. Cover crops in orchards appear to check erosion effectively. Considerable erosion may occur on clean-cultivated fields or in orchards and grain fields. The degree of erosion depends greatly on the season. If gentle early rains promote good growth of grain or cover crops before the heavy winter rains, little erosion occurs. If there are no early gentle rains to start the grain and cover crops or weeds, erosion may be severe on the unprotected soil.

Near Arcade these soils are planted to dry-farmed grain, and in the Carmichael, Fair Oaks, Citrus Heights, and Orangevale districts they are used for a wide variety of fruits. Yields of grain are fair, but fruit yields are extremely variable. Olives and almonds do fairly well, and in a few areas citrus trees grow reasonably well, but yields are uncertain due to frost hazard. Other fruit and nut crops are peaches, plums, prunes, nectarines, apricots, grapes, and walnuts. These are not extensively grown, and yields are comparatively low.

Most holdings are made up of only a few acres, on which several kinds of fruit trees, some poultry, and usually an acre or two of Ladino clover or Sudangrass for forage are raised. Since these are only part-time farms, the soils and crops are not managed to give maximum yields.

Whitney fine sandy loam, rolling and hilly (8–25 percent slopes) (WD).—The surface soil is light-brown or nearly reddish-brown, friable fine sandy loam with a strongly to slightly acid reaction (pH 5.0 to 6.5). The color varies considerably but is dominantly more brownish on the knolls and crests of small ridges and more reddish on the slopes.

The subsoil, at depths of 6 to 24 inches, is slightly redder and of similar or slightly finer texture. The reaction is about the same as for the surface soil or slightly less acid (pH 5.5 to 7.0). At a depth of 25 to 35 inches, the subsoil may rest abruptly on softly consolidated pale-brown, grayish-brown, or light brownish-gray stratified sedimentary deposits of sand and clay. In places a layer of brown or reddish-brown clay or sandy clay, which is plastic and sticky when wet, lies directly above the bedrock. This clay or sandy clay layer probably represents a zone of finer textured stratified weathered bedrock.

Slopes are short, and the bedding planes of the bedrock are nearly horizontal. The material appears to have been originally a nearly flat plain with a gentle westward slope into which drainageways have cut in a dendritic pattern.

The original cover was mostly grasses and oaks up to about 2 feet in diameter. Only a few small virgin areas remain in woodlots, and most of the soil has been cleared and farmed for some time. Good stands of annual grasses and other pasture plants are produced. Grain, mostly dry-farmed wheat, is the principal crop near Antelope. Summer fallowing is usual. The Fair Oaks, Carmichael, Citrus

Heights, and Orangevale districts have been subdivided into 1- to 20-acre residential and garden areas, the owners of which derive part of their income from work in Sacramento or in the railroad shops and yards at Roseville (in Placer County).

Citrus fruits, deciduous fruits, grapes, berries, vegetables, and some Ladino clover are grown. Many farmers raise some chickens, a cow or two, tend a small orchard made up of a number of kinds of fruit trees, some Ladino clover or Sudangrass, and some grapes, olives, and almonds. Under such part-time farming, proper care cannot be given to trees or vines, and yields are usually low and of inferior quality. Olives and almonds do better than other orchard crops. Citrus fruits are often injured by frosts, which make their culture economically uncertain.

This soil is fairly erosive. Clean-cultivated fields and some fallow land and grain fields show considerable evidence of erosion. Pastures or orchards protected by cover crops or a good growth of weeds during the rainy season are very little eroded. No erosion control measures other than cropping systems were in evidence during the survey.

Whitney fine sandy loam, steep (25+ percent slopes) (We).—This soil is found in the narrow ravines formed by drainageways that empty into the American River and on the bluffs above the river. The slopes, particularly along the bluffs, are very steep and are precipitous in places.

The soil profile consists mainly of fine sandy loam material above the bedrock. A sandy clay or clay layer does not occur so frequently as it does in more gently sloping areas.

The cover, mostly of oak trees with some grass undercover, fairly adequately protects against erosion, which is slight. Some areas are pastured to sheep or cattle; others are unused. Practically none are cultivated.

Whitney fine sandy loam, undulating (3–8 percent slopes) (Wf).—This soil is similar to Whitney fine sandy loam, rolling and hilly, but a clay layer just above the bedrock is more characteristic of this soil and its surface layer has a more pronounced red tint. This soil appears to be a transition between the Whitney and San Joaquin soils.

The 8- to 16-inch surface soil is light-brown or nearly reddish-brown, friable fine sandy loam. It is underlain by material of similar texture but of slightly redder color, and below that is a compact, reddish-brown clay layer. The bedrock, at a depth of 30 to 40 inches, is softly consolidated, stratified, sandstonelike material.

Dry-farmed grain is the principal crop. Yields are similar to those from Whitney fine sandy loam, rolling and hilly, but considerably better than yields from San Joaquin sandy loam, undulating, which it joins on the west. A little erosion occurs on grain fields during the rainy season, though less than on more sloping soils.

Whitney fine sandy loam, deep, undulating and rolling (3–15 percent slopes) (Wc).—The surface soil is friable brown or light reddish-brown fine sandy loam that may contain a little more mica than the corresponding layer in other Whitney soils. The upper subsoil, extending to depths of 24 to 48 inches, is reddish-brown sandy clay loam. This part of the subsoil is moderately compact and somewhat sticky when wet, although moisture and plant roots penetrate it easily. The lower subsoil is unconsolidated light reddish-brown sandy clay loam

that extends to depths of 5 to 8 feet. It is underlain by softly consolidated sandstone materials similar to those under Whitney fine sandy loam, rolling and hilly.

Because of the deeper profile, orchard trees grow better than on Whitney fine sandy loam, rolling and hilly. Almond orchards yield about half as much as on the deep friable alluvial soils.

Clean-cultivated orchards and some areas in grain erode severely during the rainy season, but cultivated areas protected by cover crops or weeds are very little affected. Management of crops and cropping systems are much the same as on Whitney fine sandy loam, rolling and hilly, but more of the area is used for small orchards and less for grain.

Whitney gravelly sandy loam, rolling (8–15 percent slopes) (WG).—The surface soil is 8 to 20 inches of brown, pale-brown, or light-brown, friable gravelly sandy loam. The gravel consists mostly of well-rounded quartz or quartzite fragments up to about 3 inches in diameter. The subsoil, extending to depths of 15 to 36 inches, is light-brown or light reddish-brown gravelly sandy loam or gravelly loam, a little redder than the surface soil but little if any more compact. It is underlain in some places by a thin clayey layer that contains some gravel. The bedrock, at depths of 24 to 40 inches, consists of light-brown softly consolidated sandstone and conglomerate. The surface soil is medium to slightly acid (pH 5.5 to 6.5), and the subsoil is a bit more acid than the surface layer.

This soil occurs in scattered bodies associated with Whitney fine sandy loam, rolling and hilly. The gravel interferes somewhat with tillage and yields of grain or fruit are less than on comparable slopes of the gravel-free soil.

RELATIVE SUITABILITY OF SOILS FOR AGRICULTURE

The aim of efficient land use and management is to produce a good income over a period of years and to maintain productivity at a high level. To achieve this, farmers have to use their land for purposes to which it is well suited and follow management practices that will maintain or build up the fertility of the soil and minimize erosion. Among these practices are irrigation, crop rotation, tillage methods, and applications of manures and fertilizers. In a good management system, the farmer tries to take advantage of a soil's good points and to overcome its deficiencies.

The intensive and highly specialized agriculture of the Sacramento Area is almost entirely dependent on irrigation. Some of the important crop management practices, including those directly related to certain crops, are given in the section on Agriculture. Important characteristics of the soils and conditions governing their use are given in relative descriptive terms in the map supplement.

In table 5 the soils of the Sacramento Area are arranged in alphabetical order and rated according to the Storie Index (*12*), which is a numerical rating showing the relative physical suitability of a soil, or its value for general intensive agriculture. Considered in the index are: (1) character of the soil profile and soil depth; (2) texture of the surface soil, and (3) other modifying factors such as drainage, alkali, infertility, erosion, and slope. The index does not take into consideration other physical or economic factors that might determine the desirability of growing certain crops in a given locality. Thus, the index in itself cannot be regarded as a standard for evaluating land.

TABLE 5.—*Storie index rating of the soils of the Sacramento Area, California*

Soils	Soil characteristic rating			Index rating	Sub-class	Class or grade
	A Soil profile, depth, and slope	B Surface texture	C Other factors			
	Percent	*Percent*	*Percent*			
Alamo clay (adobe), nearly level	35	60	100	21	4A	4
Amador fine sandy loam:						
Rolling and hilly	20	100	[1] 60	12	5A	5
Steep	15	100	[2] 18	3	6A	6
Undulating	25	100	[1] 60	15	5A	5
Auburn stony loam:						
Rolling and hilly	35	70	100	25	4B	4
Steep	30	70	[3] 30	6	6A	6
Undulating	40	70	100	28	4B	4
Ayar clay loam, rolling and hilly	45	85	100	38	4B	4
Bear Creek gravelly loam, very gently sloping	85	70	[4] 64	38	4A	4
Burns silty clay loam, nearly level	95	90	[5] 60	51	3B	3
Chualar gritty clay loam, nearly level	90	75	95	65	2B	2
Chualar gritty loam:						
Channeled, very gently sloping	90	90	[6] 50	41	3C	3
Very gently sloping	90	90	95	77	2B	2
Columbia fine sandy loam:						
Channeled, nearly level	100	100	[6] 50	50	3C	3
Nearly level	100	100	100	100	1A	1
Overflowed, nearly level	100	100	[7] 55–85	55–85	2B	1–3
Columbia fine sandy loam (over Freeport clay), nearly level	100	100	[8] 80	80	1B	1
Columbia fine sandy loam (over Sacramento silty clay loam), nearly level	100	100	[8] 90	90	1B	1
Columbia loamy fine sand:						
Channeled, nearly level	100	90	[9] 45	41	3C	3
Nearly level	100	90	[10] 80	72	2A	2
Overflowed, nearly level	100	90	[7] 45–70	41–63	3C	2–3
Columbia loamy fine sand (over Freeport clay), nearly level	100	90	[11] 70	63	2B	2
Columbia silt loam:						
Nearly level	100	100	100	100	1A	1
Overflowed, nearly level	100	100	[7] 55–85	55–85	2B	1–3
Columbia silt loam (over Freeport clay), nearly level	100	100	[8] 80	80	1B	1
Columbia silt loam (over Sacramento silty clay loam), nearly level	100	100	[8] 90	90	1B	1
Columbia silty clay (over Freeport clay), nearly level	100	75	[8] 80	60	2B	2
Columbia silty clay (over Sacramento silty clay):						
Nearly level	100	75	[12] 90	67	2B	2
Overflowed, nearly level	100	75	[7] 50–75	38–56	3C	3–4

See footnotes at end of table.

TABLE 5.—*Storie index rating of the soils of the Sacramento Area, California*—Continued

Soils	Soil characteristic rating			Index rating	Sub-class	Class or grade
	A Soil profile, depth, and slope	B Surface texture	C Other factors			
	Percent	*Percent*	*Percent*			
Corning gravelly loam, undulating	60	[13] 60	100	36	4A	4
Dorado stony silt loam:						
Rolling and hilly	20	70	[1] 70	10	5A	5
Steep	15	70	[2] 21	2	6A	6
Freeport clay (adobe), nearly level	80	60	[5] 70	34	4A	4
Glann loam, nearly level	40	100	[14] 90	36	4A	4
Hanford loamy fine sand:						
Channeled, nearly level	100	90	[6] 50	45	3C	3
Nearly level	100	90	100	90	1A	1
Overflowed, nearly level	100	90	[7] 55–85	50–76	2B	2–3
Hanford sand, overflowed, nearly level	100	60	[15] 45–70	27–42	4A	3–4
Hanford very fine sandy loam:						
Channeled, nearly level	100	100	[6] 50	50	3C	3
Nearly level	100	100	100	100	1A	1
Overflowed, nearly level	100	100	[7] 55–85	55–85	2B	1–3
Holland sandy loam, rolling and hilly	50	95	100	48	3D	3
Honcut gravelly loam, nearly level	100	70	100	70	2A	2
Honcut loam:						
Channeled, nearly level	100	100	[6] 50	50	3C	3
Nearly level	100	100	100	100	1A	1
Overflowed, nearly level	100	100	[7] 55–85	55–85	2B	1–3
Honcut loam (over San Joaquin hardpan substratum), nearly level	100	100	[4] 75	75	2C	2
Honcut very fine sandy loam:						
Nearly level	100	100	100	100	1A	1
Overflowed, nearly level	100	100	[7] 55–85	55–85	2B	1–3
Honcut very fine sandy loam (over Bear Creek gravelly loam), overflowed, very gently sloping	90	[16] 90	[17] 30–65	24–53	4A	3–4
Kitchen middens	------	------	------	[18] 10–40	4A	3–5
Oakley loamy fine sand (over Glann loam), undulating	100	90	[19] 60	54	3A	3
Oakley sand, undulating	100	50	[20] 80	40	3A	3
Pentz loam:						
Rolling and hilly	50	100	100	50	3D	3
Steep	50	100	[3] 30	15	5A	5
Pentz-Redding gravelly loams:						
Rolling and hilly	30–40	70	100	21–28	4B	4
Steep	30–40	70	[3] 30	6– 8	6A	6
Undulating	30–50	70	100	21–35	4A	4
Pentz sandy loam:						
Rolling and hilly	50	95	100	48	3D	3
Steep	50	95	[3] 30	14	5A	5
Perkins gravelly loam, very gently undulating	85	70	100	60	2C	2

See footnotes at end of table.

TABLE 5.—*Storie index rating of the soils of the Sacramento Area, California*—Continued

Soils	Soil characteristic rating			Index rating	Subclass	Class or grade
	A Soil profile, depth, and slope	B Surface texture	C Other factors			
	Percent	*Percent*	*Percent*			
Peters clay (adobe), rolling and hilly	60	60	100	36	4B	4
Placer diggings	------	------	------	[18] 1–5	6B	6
Redding cobbly loam, undulating	20	50	100	10	5A	5
Redding gravelly loam, undulating and rolling	30	70	100	21	4A	4
Riverwash	------	------	------	[18] 1–5	6B	6
Rydberg loam, very gently sloping	100	100	[1] 61	61	2A	2
Sacramento silty clay loam:						
Nearly level	95	90	[12] 90	77	2B	2
Overflowed, nearly level	95	90	[7] 50–75	43–64	3C	3
San Joaquin loam-Alamo clay (adobe), very gently undulating	30–35	60–100	100	18–35	4A	4
San Joaquin loam:						
Deep, undulating	60	100	100	60	2C	2
Undulating	25	100	100	25	4A	4
Very gently undulating	30	100	100	30	4A	4
San Joaquin sandy loam:						
Deep, undulating	60	95	100	57	3D	3
Undulating	25	95	100	24	4A	4
Very gently undulating	30	95	100	29	4A	4
Scabland	------	------	------	[18] 1–5	6B	6
Siskiyou-Holland sandy loams:						
Rolling and hilly	30	[21] 65	100	20	4B	4
Stony and steep	20	65	[3] 30	4	6A	6
Slickens	------	------	------	[18] 20–60	3C	2–4
Tailings	------	------	------	[18] 1	6B	6
Terrace breaks (Redding-Corning soil materials), steep	------	------	------	[18] 5	6A	6
Whiterock stony loam:						
Rolling and hilly	20	70	100	14	5A	5
Steep	20	70	[3, 21] 30	4	6A	6
Whitney fine sandy loam:						
Deep, undulating and rolling	70	100	100	70	2C	2
Rolling and hilly	50	100	100	50	3D	3
Steep	50	100	[3] 30	15	5A	5
Undulating	60	100	100	60	2C	2
Whitney gravelly sandy loam, rolling	50	65	100	33	4B	4

[1] Soil acid and relatively infertile.
[2] Soil acid, relatively infertile, excessively steep slopes.
[3] Excessively steep slopes.
[4] Stratified subsoil, rare overflow.
[5] Poorly drained.
[6] Channeled, overflowed.
[7] Overflowed.
[8] Soil imperfectly drained and underlain by finer textured material.
[9] Channeled, subsoil stratified, and overflowed.
[10] Stratified subsoil.
[11] Shallow stratified alluvial soil underlain by finer textured material.
[12] Imperfectly drained.
[13] Gravelly and somewhat cobbly.
[14] Imperfectly drained, overflowed.
[15] Slightly wind modified, overflowed.
[16] Textures somewhat variable within short distances.
[17] Shallow overwash, overflowed.
[18] Estimated; not obtained through use of factors.
[19] Slightly wind modified and underlain by finer textured soil material.
[20] Wind modified.
[21] Rock outcrop.

According to index rating, the soils are placed in six classes or grades. Class 1 soils, with ratings of 80 to 100, are excellent soils well suited to general intensive agriculture. They are easily worked; their productivity can be easily maintained or improved; their topography is such that they are not difficult to irrigate; and they are not subject to erosion.

Class 2 soils, which are rated from 60 to 79, are moderately well suited to agriculture. They are easily irrigated and do not need special erosion-control measures. The range of crops and the yields are somewhat less than for class 1 soils. Productivity is more difficult to improve or maintain.

Class 3 soils, only fairly well suited to general intensive agriculture, are rated from 40 to 59. They have a smaller range of crops and lower yields than class 2 soils and are more difficult to irrigate. Some soils of this class require special erosion- and flood-control practices.

Class 4 soils are poorly suited to general intensive agriculture; they rate from 20 to 39. They have a narrow crop range, produce low yields, and are marginal soils for intensive agriculture.

Soils very poorly suited to intensive agriculture are in class 5 and have ratings of 10 to 19. They are essentially nonarable, but may be used for pasture.

Soils and miscellaneous land types without agricultural value are rated less than 10, and make up class 6.

These soil classes, or grades, have been divided into subclasses on the basis of the general nature of the soil limitations that affect agricultural use.

Subclass 1A soils are deep and well suited to orchard, field, and truck crops. They are subject to no significant limitations in crop production.

Subclass 1B soils are deep, but their drainage is not perfect. They are as well suited to field and truck crops as subclass 1A soils, but somewhat less well suited to orchard crops.

In subclass 2A are deep, well-drained soils of less favorable surface or subsoil texture or lower fertility than those in preceding subclasses. They are suitable for orchard, field, and truck crops, but not so well suited as soils in subclass 1A.

Subclass 2B soils are deep imperfectly drained soils, well suited to field and truck crops but only fairly well suited to most orchard crops. Included in subclass 2B are some soils subject to periodic overflow.

Subclass 2C soils are moderately deep well-drained soils that have undulating or rolling relief, or a moderately compact subsoil. They are moderately to relatively well suited for orchard, field, and truck crops but they are more difficult to irrigate efficiently than soils in subclasses 2A and 2B.

Subclass 3A soils are well-drained, coarse-textured, and difficult to maintain at proper moisture content. They are moderately well suited to special crops.

Subclass 3B soils are poorly drained, highly organic, suited to certain special crops, but very poorly suited to orchard crops.

The soils in subclass 3C are stratified and channeled, or subject to periodic overflow. Their suitability for crops depends mainly on the degree to which they can be protected from overflow. The miscellaneous land type, Slickens, is a member of this group.

In subclass 3D are the moderately deep to moderately shallow, undulating, rolling, or hilly soils that require special practices in irrigation and erosion control.

In subclass 4A are soils underlain by hardpans, claypans, or consolidated substrata, or fine-textured soils, or stratified soils subject to overflow. They are fairly well suited for some field crops.

Subclass 4B soils are relatively shallow soils that are mainly rolling to hilly. They are suitable for irrigation only under very special practices. Intensive erosion control measures are required where they are to be cultivated.

Subclass 5A soils are shallow. They range from rolling to hilly or steep, and some are cobbly and stony. They are best used for range pasture.

Subclass 6A soils are shallow, steep, and usually stony. In general, they are relatively poor, even for range pasture.

Subclass 6B soils are composed of nonagricultural miscellaneous land types.

Table 6 groups the soils of the area by subclasses and gives the suitability of each for principal crops. The classification considers the climatic requirements and the probable yield and quality of different crops under common management practices, the feasibility of using irrigation, and, for perennial crops, the probable productive life.

EXPECTABLE ACRE YIELDS

Table 7 connects the crop suitability terms given in table 6 into ranges of yield per acre for principal crops. These expectable ranges of yield are based on the management practices commonly used in the area at the time this survey was made.

It is not practical to plant a soil to a crop to which it is very poorly suited, particularly where production is to be on a commercial scale, although some success may be possible on poorly suited soils under very special management. Crop yields under common management practices on soil of fair suitability approximate the present average yield in the region. Under this management the success of the enterprise is largely determined by current prices and by management skills. Assuming that the farmer uses crop and farm management practices common to the area and prices are normal, the production of a crop on soils of good or very good suitability should be successful.

TABLE 7.—*Expectable range of yield per acre for principal crops in the Sacramento Area, Calif., according to crop-suitability terms given in table 6*

[Yields are based on the management practices commonly used in the area at the time of survey.]

Crop (irrigated)	Unit	Crop suitability term: Very good	Good	Fair	Poor	Very poor
		More than		*Less than*	*Less than*	
Almonds	Pounds	1,000	600–1,000	300–600	300	
Plums, fresh	Tons	5	3–5	1½–3	1½	
Prunes, dried	do	4	2–4	1–2	1	
Pears, fresh	do	8	6–8	4–6	4	
Olives	do	3	1½–3	½–1½	½	
Grapes, fresh	do	9	5–9	2½–5	2½	Very low or no yields of commercial importance.
Tomatoes, fresh	do	12	8–12	5–8	5	
Spinach	do	8	5–8	2–5	2	
Alfalfa hay	do	6½	5–6½	3½–5	3½	
Sugar beets	do	20	16–20	12–16	12	
Wheat	Sacks, 120-lb	18	13–18	8–13	8	
Wheat [1]	do	12	9–12	5–9	5	
Grain sorghum	Sacks, 110-lb	30	22–30	14–22	14	
Rice	Sacks, 100-lb	40	30–40	20–30	20	
Beans, dry	do	15	11–15	7–11	7	
Barley	do	25	18–25	11–18	11	
Barley [1]	do	16	12–16	7–12	7	
Oats	Sacks, 80-lb	25	18–25	0–18	10	
Oats [1]	do	17	13–17	17–13	7	
Pasture, Ladino clover.[2]	Cow-acre-days.[3]	400	300–400	200–300	200	
Pasture, range [4]	do	50	25–50	15–25	5–15	Less than 5

[1] Nonirrigated.

[2] Ladino pastures consist of areas seeded and irrigated for pasture in which Ladino clover is the main constituent.

[3] The term "cow-acre-days" is used to express the carrying capacity or grazing value of pasture or range. It equals the number of days of grazing 1 acre will provide for 1 aninal unit. 1 animal unit is a mature cow, steer, or horse, or 5 mature sheep.

[4] Range pasture consists of natural forage on areas not cultivated or irrigated.

WATER CONTROL ON THE LAND

The Sacramento Area is in a region where the average annual precipitation is less than 20 inches, so the availability of irrigation water largely determines the use of the land. Dry-farmed crops, which are widely raised, depend entirely on the precipitation that falls in the rainy season from November to April. Several rivers and creeks that cross the area drain the foothills in the eastern part and empty into the Sacramento River, which is the western boundary of the area. In some places, however, farmers depend on wells to supply a part or all of the irrigation water.

The area is divided into four more or less parallel physiographic divisions, each of which extends the full length of the area in a north-south direction. The two eastern zones are used only for grazing, or

to a limited extent for dry-farmed grain, whereas the two western zones are irrigated or drained, or both, and cultivated to a variety of crops.

The first zone, adjacent to the Sacramento River on the western side of the area, is marshy and requires drainage before it can be cultivated. It lies at or near sea level, and, although largely protected by levees, the land is still subject to overflow and seepage waters from the Sacramento River and its tributaries.

The second zone, farther to the east than the first zone, is level or gently rolling and has somewhat restricted drainage. It requires irrigation and sometimes drainage, but has no erosion problem.

The third zone, which is east of the second zone, consists of the reddish, cobbly, sloping terraces of the outer fringe of the low foothills. It is not suitable for irrigation and is subject to moderate erosion.

The fourth zone, the one farthest east, consists of the sharply rolling or steep foothills. It cannot be irrigated and is seldom cultivated. Erosion would be a serious problem if the soils were not protected by a grass cover.

CONTROL OF RUNOFF

Runoff is the water removed from the soil by surface flow during and shortly after rains. Erosion normally takes place in cultivated areas where runoff is not controlled. The problem of erosion, where important, is considered in some detail in the descriptions of individual soil types and is discussed here only in broad perspective.

The two zones in the western half of the area are either nearly level or have a depressed relief; consequently, the problem they present is retarded runoff, not accelerated runoff. The greatest differences in relief are in the easternmost zone. In this section, geologic erosion over long periods of time has resulted in a hilly relief characterized in places by steep and short slopes. Since very little of this zone is cultivated, most of the soil is protected from erosion throughout the year by a grass cover. Some sheet and gully erosion does occur, however, on the Amador soils, which support only a scant vegetative cover.

The undulating and gently rolling zone adjacent to the hilly eastern region is subject to moderate sheet and gully erosion. These soils are derived from parent materials that range from coarse sandy to large cobbly material. In addition, relatively impervious bedrock, hardpan, or claypan occurs at shallow depths, causing the soils to become saturated relatively quickly and the rest of the rainfall to run off the surface.

Plowed fields, or fields in which grain has been planted in fall, are subjected to moderate or severe sheet and slight gully erosion during winter. The region north of the American River planted to citrus fruits erodes badly if the soils are left bare over the winter or are cultivated up and down rather than across the slope. Where protected by a grass or heavy weed cover, however, very little erosion is discernible even during exceptionally wet winters. In this region it is advisable to leave an adequate cover of weeds or grass on the soil in. fall. Where this is not practical, contour tillage is highly desirable.

DRAINAGE

Drainage is a constant problem on all lands adjacent to the Sacramento and North Fork Mokelumne Rivers along the western and southwestern borders of the area. Large levees now line the banks of these streams; they confine winter and spring floodwaters to definite areas and prevent the inundation of extensive and valuable farm lands. The construction of the levees left extensive areas of marsh and lowlands in need of drainage, not only because of the normal high water table, but to take care of water discharged by the numerous small streams that originate in the eastern two-thirds of the county. Water from these streams could not reach the rivers because it was blocked by the levees.

Reclamation districts were organized to cope with this problem. Deep drainage ditches and pumping plants were installed to lift the waste water over the levees and into the major streams.

Aside from the reclamation districts, there were two drainage districts and one flood-control district in the area at the time of survey. The Sacramento and San Joaquin Drainage District, formed in 1911, includes most of the original marsh and overflow lands of both valleys and a large part of the Sacramento Area. All except two of the reclamation districts in the area are within the boundaries of this drainage district. The work of the Cosumnes Drainage District has been taken over by Reclamation District No. 1609, which it overlaps. This drainage district, organized in 1910, contains 1,900 acres. The American River Flood Control District includes 23,235 acres in the vicinity of Sacramento city. It was organized in 1927 for the purpose of controlling floods on the lower American River and in the city of Sacramento.

There were 18 reclamation districts within the Sacramento Area at the time of survey. They were organized in the period from 1880 to 1929 and ranged in size from 135 to 55,130 acres (*3*). Two districts with a total of 4,066 acres were located along the Cosumnes River, and two with a total acreage of 2,218 were located along the American River. Reclamation District No. 1000 had 69 percent of its area, or 17,090 acres, outside Sacramento County. It was the only district in the area, however, that included territory outside of the area. The remaining 14 districts were located along the Sacramento River and had a total of 68,674 acres. All of them had constructed drainage canals; all except three of the smaller districts had erected protecting levees; and most of them had a system of pumps for discharging waste water into the Sacramento River. Irrigation water for these lands was pumped either from the adjacent drainage canals or from the Sacramento River.

A considerable part of this low western region was not included within reclamation districts. Such areas, however, had benefited by the other districts. The most productive soils had been reclaimed. Because the mineral soils on the unimproved areas are very fine-textured and rest on relatively impervious substrata; tillage and drainage would be difficult and further expenditures for reclamation purposes would probably not be justified.

Considerable areas along the Cosumnes and American Rivers were without levees or had only small protecting structures. Although the soils on these flood plains, largely Hanford very fine sandy loam, are

very valuable agricultural soils, they probably do not occur in bodies sufficiently broad to justify an extensive program of levee building.

IRRIGATION

The first irrigation was done by Capt. John Sutter, who arrived in 1839. During gold-rush days, miners dug many systems of ditches in the eastern parts of the area, but only a few were ever used for irrigation, and those at a much later date. The present agriculture depends largely on irrigation water obtained from the three major rivers, small streams, and wells.

Irrigation districts.—At the time of survey, the Sacramento Area had three irrigation districts—the Carmichael, Fair Oaks, and Citrus Heights—all north of the American River and northeast of the city of Sacramento (*1*, *3*, *4*). The total area of these three districts was 10,571 acres.

The Carmichael Irrigation District, organized in 1916, had a gross area of 3,136 acres, and the average holding was 4.4 acres. In that year, permits were held for diversion of 25 cubic feet of water a second from the American River, and, in addition, 0.5 cubic foot a second was purchased from the North Fork Ditch Company for domestic use. The total diversion from the American River was 1,577 acre-feet in 1925, but it rose to 4,139 acre-feet in 1939. The water is pumped from the river, and deliveries are made to every 5 acres through a system of pipes. In 1939, 1,400 acres—planted largely to vines and orchard fruits—was under cultivation.

The Fair Oaks Irrigation District had a total of 4,268 acres within its boundaries, but only 2,450 acres was under cultivation in 1939. This area was largely planted to deciduous and citrus fruits. Although water had been bought before 1917, the district was not organized until that year. In 1939, 4,650 acre-feet of water was delivered by gravity into pipes that reached each 5 acres on demand. Each user was required to restrict his use to 1 miner's inch for each 4 acres.

The Citrus Heights Irrigation District, organized in 1920, had a gross area of 3,167 acres, of which 1,674 acres was irrigated in 1939. Vineyards and orchards cover most of the cultivated areas. Water is delivered by gravity and distributed by pipe to each 10 acres.

Diversions from the principal streams of Sacramento County, together with the total acreage irrigated, are shown in table 8. These figures do not include water diverted for municipal or mining purposes or water owned by the State. Most of the water from the Cosumnes

TABLE 8.—*Quantity of water diverted from several streams of Sacramento County, Calif.,*[1] *for irrigation, and acreage that it irrigates*

Source	Second-feet	Acreage
Cosumnes River	18. 0	1, 440
American River	42. 21	4, 374
Sacramento River	269. 33	25, 826
Linda Creek	1. 54	232

[1] Information supplied by the Division of Water Resources, State of California. The figures refer to claims licensed, approved, or pending as of Jan. 13, 1941.

River is diverted and used before the stream reaches the Sacramento Area. Diversions from the American River include 25 second-feet used by the Carmichael Irrigation District. The withdrawals from the Sacramento River are used to irrigate much of the area already discussed in the section on Drainage. Diversions from rivers account for only a part of the total acreage irrigated. Diversions are made from smaller streams, and a very large acreage is irrigated by ground water from wells.

Well-water supplies.—Supplies of well water differ according to the topographic and physiographic divisions of the area. From east to west there are three divisions where wells are important sources of water supply. These are (1) The hilly eroded belt characterized by fine-textured sand and clay bedrocks; (2) the high, gently sloping, reddish, moderately porous, cobbly terraces in the central area that give rise to the Redding soils; (3) the level plain of stratified alluvium on which the towns of Galt, Elk Grove, Florin, Mills, and Sacramento are located.

The first, or easternmost belt, is used entirely for grazing. The dense rocks of this region do not provide much water, but stock wells are located along the narrow streambeds.

The second, or east-central belt, is planted to dry-farmed grain or used for grazing. Water is available in limited quantity, but it is almost never used except for livestock. Here, too, almost all the active wells are along the streams. In this belt, as well as in the first, water from wells is supplemented by many small reservoirs formed by building earth dams across ravines near the upper end of small drainage systems. These reservoirs, many of which are shown on the soil map, fill during winter and often contain some water the entire year. They are a valuable addition to the water supply. Demand for livestock water is light during summer and early fall, as almost all stock is grazed elsewhere.

The third belt, that lying west of the foothills, is planted to grain, Ladino clover, vines, and some vegetable crops. Demand for water becomes greater as more land is planted to crops that need frequent irrigation in summer. Some water is lost in transit from the source of supply to the field, the quantity depending on the distance carried and on the permeability of the soils through which the delivery canal passes.

In this third belt the average water requirements for the common farm crops, as based on actual quantity of water used at the farm, are compiled by the United States Bureau of Reclamation as follows:

Crop	*Acre-feet of water per season*	*Crop*	*Acre-feet of water per season*
Alfalfa	3. 07	Tomatoes	1. 59
Sudangrass	1. 55	Sugar beets	2. 15
Rice	7. 23	Beans	1. 15
Ladino clover	4. 49	Grain sorghum	1. 07
Prunes	1. 52	Irrigated pasture	1. 62
Walnuts	1. 98	Peas	. 67

The city of Sacramento is in this third belt. Near the city the most satisfactory water-bearing strata occur at depths of less than 300 or 400 feet; deeper wells produce water of inferior quality (*9*). The surface strata are irregular lenses of sand, gravel, and clay of varying densities. The best wells are those that tap water in sand and gravel

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layers, but these layers are so irregular in occurrence that logs of adjacent wells are of little help in locating new ones. The gradient of these underground water-bearing strata is about 4 feet to the mile toward the west, but the gradient of the land surface is about 5 feet to the mile. Wells along the west side of the area therefore need not be so deep as those along the margin of the low foothills.

The low gradient of the water-bearing strata and the discontinuity of the porous layers causes very slow lateral movement of the underground water. This slow movement is responsible for the slow rate at which the underground reservoir is replenished when water is removed by pumping. The rise in the water table during the rainy months indicates that much of the ground water is restored by surface penetration, not by seepage from the American or Cosumnes Rivers. The water table depends largely on the variations in seasonal rainfall. Nevertheless, along the narrow flood plains of these rivers, shallow wells that irrigate large areas depend directly on the water table maintained in these streams.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of the environment acting upon the parent materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by: (1) The physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the relief or lay of the land, which determines the local and internal climate of the soil, its drainage, moisture content, aeration, and susceptibility to erosion; (4) the biologic forces acting upon the soil material, the plants and animals living upon and in it; and (5) the length of time the climatic and biological forces have acted upon the soil material.

The soils of this area are formed under rather uniform climatic conditions. There are two seasons—a mild rainy winter and a hot dry summer. The average annual rainfall is between 17 and 20 inches for most of the area. Of this, about three-fourths falls from December through April. Winters are mild. The few frosts occurring from mid-November through February are never severe enough to freeze the soil. Summer temperatures are high, reaching a maximum of 110° F. during the day. The temperature is somewhat moderated nearly every evening, however, by ocean breezes through the gap in the coastal mountains formed by the Golden Gate and Carquinez Strait. Although rainfall is not excessive, that which falls during the rainy season is sufficient to saturate all of the upland and most of the older alluvial soils. This gives a humid climate during the rainy season, and a practically rainless arid climate in summer.

The soils saturated in winter are more subject to erosion than those with free subdrainage. Erosion is also active where vegetation is sparse, but it tends to vary from season to season on grazing land. In seasons of mild early rains, which give the vegetation a good start before the period of heavy rains, erosion is not severe; but, in seasons when early rains fail to materialize or when the early part of the normal growing season for grasses is so cold that the growth of the grasses is delayed until the heavy rains start, excessive erosion occurs. The rate and degree of erosion are increased by overgrazing or tillage.

The saturation of soils during winter also affects the processes of soil development. The end of the rainy season is usually accompanied by winds, which together with the shallow-rooted annual grasses that make practically all of their growth during the rainy season, desiccate the surface soils and upper subsoils and leave the finer textured deeper subsoils to dry out much more slowly. The prolonged period in which the subsoils are wet and the surface soils are dry probably accentuates weathering in the subsoils and profile development. Nearly all of the older soils on valley-filling materials have small iron pellets in the middle and lower subsoils, especially where they are underlain at moderately shallow depths by hardpanlike substrata.

Most of the soils of this area are alluvial in origin, being derived from parent materials transported into the valley from the Sierra Nevada. Some soils developed in place from bedrock material at the eastern edge of the valley are included in this area. Both the residual and alluvial soils are derived from a wide variety of rocks and rock formations, and some are very old.

The geology of the Sierra Nevada foothills is complicated, and not much geological investigation has been done, especially on the lower foothills and valley sediments. The report by Lindgren and Turner (*10*) on the geology of the upland areas gives little detail about the foothills and valley floor. Most of these lower formations, however, have been remapped and redefined in more recent works by other geologists (*2*, *11*).

The paper by Allen (*2*) redefining the Ione formation and some related formations also points out the complexity of the sedimentary rock formations of the lower foothills of the Sierra Nevada. The paper by Piper and others (*11*), which follows the definitions of Allen, gives a detailed mapping of a number of formations, not only of the softly consolidated sedimentary rock formation of the foothills but also of the valley alluvium. This work covers only the southern half of Sacramento County, but the descriptions and definitions of the formations are sufficiently clear that they can be easily recognized in locations farther north.

The soil series, because of the close relation of dominant characteristics to parent material and stage in profile development, are divided into four physiographic and geographic groups and several subgroups:

I. Soils of the upland developed on consolidated bedrock:
  A. Soils underlain by hard bedrock of—
    1. Basic igneous rocks:
      Auburn series on andesitic rocks and amphibolite schist, pre-Cretaceous.
    2. Acid igneous rocks:
      Holland series on granodiorite, pre-Cretaceous.
      Siskiyou series on granodiorite, pre-Cretaceous.
    3. Metamorphosed rocks:
      Whiterock series on Mariposa slates, Jurassic.
      Dorado series on schist, Jurassic.

I. Soils of the upland developed on consolidated bedrock—Con.
  B. Soils underlain by softly consolidated sedimentary bedrock:
    Amador series on Valley Springs formation, rhyolite tuff, Miocene; and on Ione formation, nontuffaceous, Eocene.
    Whitney series on Laguna formation, Pliocene or early Pleistocene.
    Pentz series on Mehrten formation, from andesitic detritus, Miocene.
    Peters series on Mehrten formation, from andesitic detritus, Miocene.
    Ayar series on marly shale, formation and age not known.
II. Soils developed on recent and young flood plains and alluvial fans:
  A. Chiefly from acid igneous materials:
    Hanford series on granitic alluvium, recent.
    Chualar series on granitic alluvium, recent.
  B. Chiefly from basic igneous materials:
    Honcut series on andesitic alluvium, recent.
  C. From mixed materials:
    Columbia series on alluvium along major streams, recent.
    Bear Creek series on alluvium along intermittent streams, mostly from Redding, Pentz, and Peters soil materials, recent.
    Oakley series on alluvium from major streams, reworked by wind, recent.
    Rydberg series on alluvium from Amador soils, recent.
III. Soils developed on old alluvial plains and terraces:
  A. Soils on higher terraces:
    Corning series on Arroyo Seco and other Pleistocene gravels.
    Redding series on Arroyo Seco and other Pleistocene gravels, often underlain by Laguna or Mehrten formations at fairly shallow depths.
  B. Soils on lower terraces and old alluvial plains:
    Perkins series on Arroyo Seco and other Pleistocene gravels.
    San Joaquin series on Victor formation, late Pleistocene.
    Alamo series on Victor formation, late Pleistocene.
    Glann series on Victor formation, late Pleistocene.
IV. Soils developed in alluvial basins:
    Sacramento series on basin alluvium from major streams, recent.
    Freeport series on basin alluvium from major streams, recent.
    Burns series on mixed highly organic material and alluvium from major streams, recent.

The soils of the uplands and those on recent alluvial deposits owe their major differences to variations in source of parent material. Characteristics of soils on old valley fillings and in the alluvial basins are determined less by differences in parent materials than by differences in drainage or stage of profile development.

SOILS OF THE UPLANDS DEVELOPED ON CONSOLIDATED BEDROCK

The soils of the upland are made up of 10 series, of which 5—Auburn, Dorado, Holland, Siskiyou, and Whiterock—are derived from comparatively hard bedrock and the other 5—Amador, Whitney, Pentz, Peters, and Ayar—are derived from softly consolidated bedrock. Those derived from the harder bedrock are divided into three categories according to the source of the parent materials. A discussion of these soil series follows.

UPLAND SOILS DERIVED FROM COMPARATIVELY HARD BEDROCK

AUBURN SERIES

The soils of the Auburn series are derived from basic igneous rocks, almost wholly from andesites and amphibolite schist. These rock materials are fine-grained, hard, and very dense. The derived soils are normally shallow and rest directly on hard bedrock with only a thin zone of softer crumbling bedrock between the soil proper and the unaltered bedrock. They have a reddish color and very little profile development. They look much like the associated soils of the Dorado series, which are derived from schist. The Auburn soils are normally covered by brush or scrub oak and digger pines but have some grass-covered areas, whereas the Dorado soils of this area are almost wholly grass-covered. The Auburn soils are also closely associated with soils of the Holland and Siskiyou series, which are also derived from hard bedrock.

HOLLAND AND SISKIYOU SERIES

In the Sacramento Area the soils of the Holland and Siskiyou series appear to have been derived from essentially the same type of parent material, acid igneous rocks known as granodiorites. The Holland soil is brown or grayish brown, and the Siskiyou soil is essentially grayish brown but more gray than brown. They have slightly developed profiles. Granite outcrops in both soils, but more frequently in the Siskiyou soil. The granitic parent rocks are hard and coarse-grained, with a zone of crumbling decomposed granite between the soil proper and the harder bedrock. This weathered zone is usually deeper in the Holland than in the Siskiyou soil. The natural cover of both soil series is brush, scrub oaks, and digger pines, but the quantity of brush cover is greater on the Siskiyou soil. The Holland and Siskiyou soils occur close to the American River in the northeastern part of the area and are associated closely with soils of the Auburn series. Under natural cover, they do not erode badly, but when cleared and used for orchards or vineyards they suffer from excessive erosion.

WHITEROCK AND DORADO SERIES

The associated Whiterock and Dorado soils are derived, respectively, from slate and schist. The soils of both series are shallow or very shallow. The most striking difference between the two series is in color. The Whiterock soils are light brownish gray or pale brown, and the Dorado soils are reddish yellow or light reddish brown. All areas of Dorado soils have a grass cover, but some of the areas of Whiterock are covered with scrub oak. The tree trunks are seldom larger than 12 inches in diameter. In both series, the soils proper rest directly on hard slate or schist bedrock and have practically no

transitional zone of decomposing parent materials. In places, both the Whiterock and Dorado soils may be associated with soils of the Amador series.

UPLAND SOILS DERIVED FROM SOFTER BEDROCK

Five soil series are derived from softer bedrocks. These rock materials are of sedimentary origin, and in some instances the material is sufficiently distinct to allow identification of the original igneous rock source.

WHITNEY SERIES

The soils of the Whitney series are derived from softly consolidated stratified sand and clay, probably the Laguna formation. As described by Piper (*11*), this formation, which is not clearly exposed in the part of the Sacramento Area covered by his paper, is overlain by Pleistocene gravels; however, the main area of Whitney soils in the vicinity of Fair Oaks north of the American River appears to be on the same formation. This material has a general appearance similar to that of the material underlying the San Joaquin soils, which developed on the Victor formation.

The profiles of the Whitney soils vary. In some places there is very little textural change between surface and subsoil, and in others there is a clay layer from 1 inch to more than 2 feet thick resting directly on the bedrock. They also differ greatly in thickness of the weathered bedrock between the soil proper and the unaltered bedrock.

The Whitney soils are light brown or grayish brown and in places have a somewhat reddish cast. Where the profiles do not contain a clay layer they are much like those of the Pentz series except for color, but where the clay layer occurs the profiles are not greatly different from those of the San Joaquin soils.

These soils occur in the northern part of the area, almost entirely north of the American River. They are associated with the San Joaquin soils but occur at higher elevation on more hilly relief. They are also associated with soils of the Redding series, which have a similar elevation. The natural cover is oaks and grass, but most of these soils have been cleared and are farmed to grain or fruit. Erosion is active in grain fields and in clean-cultivated orchards, but where the soils are protected by grass or cover crops erosion can be successfully controlled.

PENTZ AND PETERS SERIES

The soils of the Pentz and Peters series have developed on the Mehrten formation of softly consolidated andesite detritus, probably of Miocene age. The two series are intimately associated. The soils of the Pentz series are made up of grayish-brown materials of sandy loam or loam texture derived from the coarser textured rocks of the formation.

The soil of the Peters series is derived from finer textured rocks than the Pentz and is fine textured, very dark gray or dark grayish brown, and usually of adobe structure. It is slightly acid, has very little profile development, and little change in texture throughout the profile.

Soils of both series are normally covered by a few scattered oak trees, and grass that grows vigorously and furnishes excellent pasture. They are associated with soils of the Redding and Amador series. In some places, Redding soils occupy the more nearly level terrace tops and are surrounded by Pentz or Peters soils of the marginal or escarpment slopes.

AMADOR SERIES

The Amador soils are associated with the Pentz and Peters soils, and in places with soils of the Whiterock and Dorado series. The Amador soils are derived from Valley Springs and Ione formations. These formations are mineralogically different, yet the soils produced on each are similar in general appearance. They vary somewhat in color but are mostly light brownish gray or pale brown. Much of the brownish or reddish color is derived from remnants or thin cappings of gravelly materials similar to those giving rise to the Redding soils. Both the Valley Springs and Ione formations consist of moderately soft, light-colored, sandy or clayey rocks. Soils from the Valley Springs formation are made up of softly consolidated detritus derived from rhyolite tuff that contains some pumice. The clay materials are usually montmorillonitic, the shaly material is highly siliceous, and the sandy material contains much quartz. In areas of conglomerate, quartz and quartzite rocks are embedded in a highly siliceous matrix. The consolidation of these conglomerates is considerably greater than of the sandstone and clay rocks. The Valley Springs formation does not overlie the Ione formation conformably, yet there are areas of Valley Springs formation resting directly on the older pre-Cretaceous rocks.

The Ione formation consists of light-gray or pinkish sandstone and light-colored clay rocks. The structure is not tuffaceous, and the clays are mostly kaolinitic. Allen (*2*) considers the Ione formation a deltaic deposit (in brackish water) of detritus from an old laterite formation, the deposition of the Ione taking place in the Eocene period.

Despite the variability of these two formations, the Amador soils derived from them are very similar in appearance, depth, and general characteristics. They are shallow, light colored, and strongly acid, and support a poor growth of grass, small oak, digger pines, or brush. Though the Amador soils are not farmed, they are considerably eroded. The erosion probably is somewhat aggravated by overgrazing, but even when they are not grazed, the natural vegetation is too sparse to give effective protection.

The material from which these soils have developed is often capped by Redding soil materials. In the vicinity of Michigan Bar, hydraulic operations have removed much of the Redding material down to the underlying Ione formation.

AYAR SERIES

The soil of the Ayar series is the only calcareous soil among the group of upland soils. It occurs in a very limited area along Carson Creek and is surrounded by soils of the Amador, Pentz, Whiterock, and Auburn series. It is developed on softly consolidated calcareous shaly material, and is brown to dark reddish brown and calcareous throughout. The subsoil is slightly finer textured than the surface soil, and the underlying material is soft and shaly. This material may be a more recent deposit in a small lake in which calcareous materials were accumulated, yet the relief is at present somewhat hilly. The close association of the Ayar series with Whiterock, Auburn, Amador, and other soils that are medium to strongly acid indicates that the soil reaction of these soils of the upland is influenced by the nature of the parent materials.

SOILS DEVELOPED ON FLOOD PLAINS AND RECENT ALLUVIAL FANS

There are seven soil series—Hanford, Chualar, Honcut, Rydberg, Columbia, Bear Creek, and Oakley—represented in this group. Nearly all of these series occupy flood plains along major streams, creeks, or minor drainage channels. These soils have permeable profiles, in most cases 6 feet or more deep. Two series have a slight degree of profile development in their subsoils, and two are made up of relatively shallow deposits resting on unrelated substrata. All of the soils of this group have inherited definite characteristics from their parent materials.

HANFORD AND CHUALAR SERIES

The soils of the Hanford and Chualar series have developed from alluvial deposits derived mostly from granitic rocks. They are stratified and highly micaceous. The Hanford soils, which are brown and have very recent profiles, are found mostly on the flood plains of the American and Cosumnes Rivers, but a few small bodies occur along some of the minor streams in the northern part of the area. Although their parent materials are mostly granitic, some basic igneous materials are intermixed. These soils occupy flat stream bottoms, and although sandy they do not contain as much quartz grit as do the Hanford soils located on many of the alluvial fans of the San Joaquin Valley and other parts of this State.

The Hanford soils are closely associated with the Columbia soils but occur farther upstream. The Columbia soils, however, are somewhat lighter in color and occur on flood plains that have higher water tables during parts of the year. The subsoils of the Columbia series are highly mottled with rust-brown iron stains, but those of the Hanford soils are usually free from mottling. Both the Hanford and Columbia soils are located where they are naturally subject to overflow from the American and Cosumnes Rivers during periods of high water. They are fairly well protected by low levees. They are suitable for a wide variety of field, truck, and orchard crops, and are some of the best agricultural soils of the area.

Soils of the Chualar series are developed on alluvial deposits, mostly from granitic rocks. They occur in the Sacramento Area only on the flood plain of Linda Creek. They are grayish brown or dark grayish brown and contain many coarse angular fragments of quartz or feldspar. Textures are medium or moderately fine. Some illuviation of clay and compaction in the subsoils, though not sufficient to interfere materially with root and water penetration, indicates a youthful stage in profile development. The medium textured types are used mostly for cherries and some alfalfa and Ladino clover, all of which do very well. The finer textured soils are used for Ladino clover or alfalfa pasture and some field crops. Ladino clover and some of the field crops do very well, but alfalfa stands are short-lived, and fruit trees do not grow on the finer textured soils. The Chualar soils are good, but are not suited to such wide uses as the Hanford soils.

HONCUT SERIES

The brown or reddish-brown Honcut soils are derived mostly from andesitic alluvium. They occur chiefly on flood plains along small or intermittent streams, but one large body is just south of the American River. The soils are stratified, gravelly in places, and usually medium

textured and friable throughout. The profiles are recent, and in places they have a small quantity of colloidal accumulation in their subsoils. This accumulation is never sufficient to influence root or water penetration.

The Honcut soils are similar to those of the Hanford series in mode of formation. Their difference is mainly in their parent material and in color inherited from the parent material. Because they occur along minor streams where the water supply is insufficient for irrigation, they are not farmed as intensely as the Hanford soils, but where water supply is adequate they can be farmed to a wide variety of fruit, field, and truck crops and will produce satisfactory yields of high quality.

RYDBERG SERIES

The inextensive soil of the Rydberg series occurs in narrow stringers along intermittent drainageways on rhyolitic tuff alluvium washed from Amador soils. The soil is light gray or light brownish gray, medium to strongly acid, and without profile development. In many places, a relatively shallow profile is underlain by the geological formations that give rise to the Amador soils. It is used only for range pasture. The grass produced is considerably better than that on the associated Amador soils.

COLUMBIA SERIES

The Columbia soils—somewhat micaceous, predominantly medium textured, stratified soils—occur extensively along the lower flood plains of all of the larger streams in association with soils of the Hanford and Sacramento series. They are light brown, pale brown, or light yellowish brown and have considerable rust-brown iron mottling throughout their subsoils. They are subject to a high water table during part of each year, and to annual overflow where not protected by levees.

The Columbia soils are derived from parent materials similar to those of the Sacramento soils, but they are younger, coarser textured, somewhat better drained, and lower in organic matter than the Sacramento soils.

In many places along the lower flood plains of the Sacramento, Cosumnes, and North Fork Mokelumne Rivers the Columbia soils are underlain at depths of less than 1 foot to 5 feet by darker colored soils, chiefly of the Sacramento series. This suggests a relatively recent increase in the alluvial deposition by these streams, perhaps a result of hydraulic mining in the Sierra Nevada foothills. Where protected from overflow, Columbia soils are excellent for a wide variety of field, truck, and orchard crops and produce good high-quality yields.

BEAR CREEK SERIES

The Bear Creek soil is derived from alluvium washed from Redding, Pentz, and Peters soils and occurs in small bodies, mainly along flood plains of small intermittent streams. It is gravelly and in places rests at shallow depth on conglomeratelike substrata similar to those underlying the Redding or Pentz soils. Some of the profiles are fairly recent and undeveloped, but others show some development. The soils are slightly to medium acid and range in color from grayish brown to dark grayish brown. As a rule they are not quite so dark as in the adjoining Lodi Area. They are used mostly for range pasture or dry-farmed

grain. Yields of grass or grain are better than on the closely associated Redding soils.

OAKLEY SERIES

Most of the inextensive soils of the Oakley series occur on the lower flood plain of the Sacramento River and are surrounded by basin areas. They were probably deposited by the Sacramento River and greatly modified by wind action. They have an undulating or dune-like topography, a uniformly sandy texture, and little profile development. They are used mostly for pasture and produce fairly good grass, but the shallow soil over Glann loam in places is used for Ladino clover or alfalfa. Yields of clover are excellent, and those of alfalfa fair.

SOILS DEVELOPED ON OLD ALLUVIAL PLAINS AND TERRACES

The soils developed on old alluvial plains and terraces—the Redding, Corning, Perkins, San Joaquin, Alamo, and Glann—are the most extensive group of soils in this area. The old alluvial valley-filling materials from which these soils have developed probably were laid down since the last major Sierra Nevada uplift in Pleistocene time. The higher terraces consist of gravelly gold-bearing deposits, probably of Pleistocene age. The deposits are somewhat stratified and contain considerable clayey material intermixed with the gravel. The lower terraces or old alluvial plains for the most part consist of nongravelly materials deposited as broad low-gradient alluvial fans or flood plains. The deposits are of mixed geological origin and contain considerable quantities of material from basic igneous rocks. Some of the deposits are loose, but by far the greater part of the sediments are somewhat cemented and hardened.

The relief of the higher terraces is undulating with fairly broad tops, but with short sharp breaks to the lower terraces. The lower terraces are less undulating; their microrelief is fairly smooth. The slope is only a few feet to the mile westward to the valley trough. The small streams, creeks, and river channels crossing the terraces and plains are so entrenched that no new alluvial deposits are being laid down.

The somewhat consolidated substrata under soils of the Redding, San Joaquin, Alamo, and Glann series undoubtedly has strongly influenced the development of their profiles. The formation of the hardpan layer at the surface of the substrata, and the accumulation of clay just above the hardpan layer, is a common characteristic of all these soils. Though the average rainfall is only about 20 inches a year, most of it is concentrated in the period extending from December through March. By the end of this rainy season there has been sufficient rainfall to saturate the soils down to the hardpan. As March winds and warmer weather come, the surface soils dry out quickly, but the subsoils remain wet for a much longer period. This may account for the development of hardpans or compact claypans in these soils.

Where the substrata are not consolidated, as in soils of the Corning series, the profile development is much deeper; and, despite the clay concentration in the subsoils, the materials are more friable. Nevertheless, internal drainage is not sufficiently rapid to absorb all water during the rainy season, and at these times the upper parts of the Corning soil are saturated. The periods of saturation are neither so

long nor so frequent, however, as in the soils underlain by impervious hardpans or substrata.

The San Joaquin, Alamo, and Glann soils are suitable only for relatively shallow-rooted crops. The San Joaquin soils are used mainly for dry-farmed grain, pasture, or Ladino clover, but considerable acreages of grapes, strawberries, and truck crops are grown on them near Sacramento, Florin, and Elk Grove. The Alamo soil is used mainly for grain or pasture. Grain yields vary, but are often poor in wet years because standing water causes winterkilling. The Alamo soil usually supports heavy stands of Italian ryegrass and makes good pasture late in spring and in summer. Ladino clover succeeds on both the San Joaquin and Glann soils, but not on the Alamo. The Glann soil is used chiefly for late spring and summer pasture. The natural cover is mostly ryegrass, which grows well on this soil. Yields of asparagus and other truck crops are only fair on Glann soil.

SOILS ON HIGHER OLD TERRACES

REDDING AND CORNING SERIES

Two soil series, the Redding and the Corning, have developed on undulating terraces considerably above the more nearly level valley plain on which the San Joaquin soils occur. They are gravelly, have strongly developed profiles, and have clay accumulations in their subsoils. The Redding soils occupy a slightly higher position than the Corning, are much more extensive, and occur from the northern border of the area to the southern boundary. The Corning soil occupies a smaller area south of the American River.

The Redding soils are underlain by softly indurated, gravelly, gold-bearing substrata that appear to be cemented with siliceous materials in the same manner as the softly consolidated Mehrten and Laguna geological formations. The substratum in most places is capped with a harder layer that appears to be a true indurated hardpan. The clay layers above the hardpan are very dense and strongly developed. During the rainy season the soils are saturated down to the hardpan, which holds up the water and forms a temporary perched water table. In many places the lower part of the clay layer resting on the hardpan is grayish because it is waterlogged part of the year. The upper part of this same clay layer is reddish brown to red and appears to be uniformly oxidized. The water seeps along the top of the hardpan and accumulates in low spots or runs off in small drainageways.

The Corning soil is similar to the Redding in appearance and relief but occurs on slightly lower terraces, and has a deeper profile and unconsolidated substratum. Although the subsoil of the Corning soil is finer textured, it is more crumbly and has better internal drainage. The absence of a hardpan has allowed weathering of the Corning soil to a much greater depth than the Redding soil. The gravel in the substrata of both soils appears to be similar. Some consolidated cobbly materials similar to those underlying the Redding soils occur in the Corning soil at depths of 8 to 15 feet.

The Redding and Corning soils are used mainly for range pasture or for dry-farmed grain, but in a few places for vineyards. The grass is only fair on these soils and is not so vigorous as on some of the upland soils, especially the Whitney, Peters, and Pentz soils. Grain

yields are also low, and grape yields are seldom satisfactory. There are few wells on these soils because the somewhat consolidated and impermeable substrata are able to furnish little water. Many homesteads, particularly on dry-farmed Redding soils, have been abandoned, but the soil is still being planted to grain. This condition is in part due to better transportation facilities which permit farmers to live in the towns, but in some instances it is due to lack of sufficient well water for domestic use.

SOILS ON LOWER TERRACES OR OLD ALLUVIAL PLAINS

There are four soil series on the lower terraces or old alluvial plains—the Perkins, San Joaquin, Alamo, and Glann. All the soils of the old valley terraces, except possibly the Perkins soil, resemble Planosols. The development of the clayey subsoils has undoubtedly been greatly influenced by the gentle relief, which permits most of the rainfall to remain in the soils and provide moisture conditions like those of more humid regions. The Perkins soil has considerably less profile development than other soils of this physiographic group, but it probably is in a stage of development similar to that once reached by the Corning soil. The San Joaquin, Alamo, and Glann soils have heavy clay subsoils resting on hardpan layers, which in turn rest on the semiconsolidated substrata.

PERKINS SERIES

The Perkins soil is formed on unconsolidated parent material consisting of gravelly deposits probably of Pleistocene age. This soil occurs on the lower terraces closer to the American River than the Corning soil, but at slightly higher elevation than the Honcut soils still nearer the river. The surface soils are brown or light brown, and the subsoils are reddish brown with considerable clay accumulation. The soil is gravelly throughout and somewhat similar to the Corning series, though not so strongly developed and as a rule not quite so reddish. Perkins soil is used for a variety of field and orchard crops. Yields are fair but not as good as on the more recent alluvial Honcut or Hanford soils. Yields are much better than those from the Redding, Corning, or San Joaquin soils in the same general location.

SAN JOAQUIN SERIES

The San Joaquin are by far the most extensive soils in the Sacramento Area. They occupy much of the broad valley plain that extends eastward from the valley trough to the high terraces. Closely associated with the San Joaquin soils is the Alamo soil, which occupies slight depressions or areas of water accumulation in the general area of San Joaquin soils, and the Glann soil, which is formed from the same type of parent materials on the margin of the valley plain adjacent to the valley trough. The Glann soil has formed under high water table conditions that exist during a part of each season. All three soils are formed from material known as the Victor geological formation, alluvium deposited during the late Pleistocene age on the floor of the valley. In this area, the deposits are of a mixed nature; they consist of materials from both acid and basic igneous rocks and also material from some metamorphosed sedimentary rock sources. The deposits are stratified, and the material is semiconsolidated and locally is referred to as hardpan.

The soils of the San Joaquin series have medium textured, light-brown or light reddish-brown surface soils and slightly finer textured and more reddish-colored upper subsoils that are porous and relatively brittle. The lower subsoils are compact reddish-brown clays of somewhat prismatic or cubical structure. The color is usually somewhat more gray just above the hardpan materials. There are numerous small iron pellets throughout the subsoils but especially in the compact clay. The hardpan layers are hard and rocklike, especially in the upper part, and often stained by manganese streaks. These harder layers are an inch to nearly a foot in thickness and rest on the semiconsolidated substrata, which vary considerably in degree of consolidation.

ALAMO SERIES

The Alamo soil has developed where surface water accumulates in small depressions in the San Joaquin soil material. The surface soil is fine textured, dark gray or dark grayish brown, and usually of adobe structure. The subsoil is clays, resting on hardpan materials which, in turn, are underlain by strata of varying degrees of consolidation. Both the San Joaquin and Alamo soils may have some segregated lime just above or in the hardpan layers, but there is more lime in the Alamo. The Alamo soil does not have a high water table. On the upper part of the valley plain the Alamo soil is associated with the San Joaquin soils; in this area it occurs in very small bodies often only 1 or 2 rods in diameter. In these locations, the subsoil is less likely to be calcareous. On the lower part of the valley plain, where the Alamo soil occurs in larger areas and has calcareous subsoil, it is similar to the Stockton soils mapped in San Joaquin County, but somewhat differs from them in position, is not so dark as a rule, and contains less lime.

GLANN SERIES

The Glann soil has developed from material similar to that underlying the San Joaquin soils, but it occurs on the margin of the valley plain, where during periods of overflow it is either covered with water or has a very high water table. The soil is dark grayish brown with considerable mottling in the subsoil, but has a sequence of textural horizons similar to soils of the San Joaquin series. Because of the high water-table prevailing for certain periods and the low marginal position on the valley plain, the occurrence of hardpan layers and degree of consolidation of the substrata are extremely variable. The quantity of iron pellets in the subsoils is greater than either the Alamo or San Joaquin soils.

SOILS DEVELOPED IN ALLUVIAL BASINS

The soils developed in alluvial basins are those of the Sacramento, Freeport, and Burns series. They are all dark colored, fine textured, and poorly drained. They occur in the valley trough along the Sacramento River at elevations ranging from 10 or 15 feet above sea level to slightly below sea level. The parent materials are well-mixed alluvium from a variety of rocks.

All the soils in the basin were subject to overflow and had a high water table under natural conditions. To be reclaimed for agricultural use, they had to be protected from overflow by levees and artifically drained to control the water table. Where reclaimed they are used for many field and truck crops but are seldom suitable for

orchard fruits. Crops such as tomatoes, beans, sugar beets, and asparagus do very well on both the Burns and Sacramento soils. Alfalfa does fairly well on the Sacramento soils, but the Burns soil is more difficult to drain, and alfalfa stands often winterkill as a result of the prolonged high water table. The Freeport soil is used for beans, grain, and sugar beets, and some rice is grown on both the Sacramento and Freeport soils in the American Basin. Yields on the Sacramento soils are generally higher than those on the Freeport soil for nearly all crops. Asparagus and tomatoes do as well on the Burns soil as on the Sacramento soils, but most other crops grow somewhat better on the Sacramento soils.

SACRAMENTO SERIES

The Sacramento soils are the most extensive of the three series. These are dark-gray or dark grayish-brown, moderately fine to fine-textured soils that have only slight profile development. The high organic-matter content of the surface soils gives them a friable consistence, low volume-weight, and an excellent and easily maintained tilth. In a few places, the subsoils may be slightly compacted and have slight lime accumulations in the lower parts. Strong mottling with iron stains occurs even in the surface soils.

The Sacramento soils are formed in a manner similar to that of the Columbia soils; but, because they occur in basin areas with very slow surface drainage and high water table, they have accumulated enough organic matter to become darker colored. The Sacramento soils are also closely related to the Burns soil, but the Burns soil material lies in still lower marshy areas where fairly large quantities of organic matter have accumulated.

BURNS SERIES

The Burns soil is not quite high enough in organic-matter content to be classified as a muck or peat but is considered transitional between organic and truly mineral soils. It occurs at elevations near sea level in the southwestern part of the Sacramento Area.

FREEPORT SERIES

The Freeport soil occurs along the eastern margin of the valley trough adjoining the valley plain. It has a slightly higher elevation than the Sacramento soils and somewhat more profile development. It is at a lower elevation than the Alamo soil and more friable, but its surface soil is somewhat similar. It has a fine texture and adobe structure. The subsoil is moderately compact and usually calcareous; it often contains a fairly large quantity of segregated lime. The parent materials are probably similar to those of the Sacramento series but may include some material washed from the San Joaquin and Alamo soils of the valley plain. Near the edge of the valley trough, the soil may be fairly shallow and rest on semiconsolidated materials similar to those underlying the soils of the lower valley plain.

LABORATORY STUDIES [6]

All samples for laboratory analysis were screened through a 2-millimeter sieve. The soil aggregates were crushed with a rubber-tipped pestle, and gravel and stones larger than 2 millimeters were

[6] This section prepared from analyses made by E. P. Perry, Division of Soils, University of California.

rubbed relatively clean. The sieved material was thoroughly mixed and aliquot parts used for the laboratory analyses.

A mechanical analysis was made of each surface-soil sample by a proximate method, in which a weighed sample of sieved soil is shaken overnight in distilled water to which sodium oxalate has been added as a dispersing agent. The sands were separated from the silt and clay by wet-sieving through a 300-mesh sieve, and then dried, weighed, and reported as total sand separate. The suspension of silt and clay that passed through the sieve was made up to one liter, shaken, allowed to stand, and sampled by means of a pipette at time intervals to give effective maximum diameters of coarse silt at 50 microns, of fine silt at 5 microns, of clay at 2 microns, and of colloidal clay at 1 micron. The results of these proximate analyses are used to check the field textural classification of surface soils and are not published.

Several representative soil profiles, however, were selected for a more complete study. Mechanical analyses of these profiles were made by the modified international method in which a weighed sample of sieved soil is pretreated with hydrogen peroxide and hydrochloric acid to remove, respectively, organic matter and carbonates. After washing free of electrolytes, dispersal is effected by shaking overnight with distilled water to which sodium oxalate has been added. The sand is separated from the silt and clay by wet-sieving through a 300-mesh sieve, and is then dried and weighed to determine the total quantity of each grade of sand. The suspension of silt and clay is sampled by means of a pipette at intervals to give effective maximum diameters of coarse silt at 50 microns, of fine silt at 5 microns, of clay at 2 microns, and of colloidal clay at 1 micron. The results of these analyses are given in table 9.

Table 10 gives the pH values, carbonates, and moisture equivalents of soils from the Sacramento Area. Moisture equivalents were determined by the standard method in which 30 grams of saturated soil is subjected to a force 1,000 times the force of gravity in a centrifuge. The moisture retained is reported as a percentage of the oven-dry weight of the soil. Where drainage is satisfactory, the moisture equivalent represents approximately the normal field-moisture capacity of the soil, or the quantity of water that is held in a soil after a heavy rain or an irrigation, when drainage downward is free and uninterrupted. Determinations of pH values were made by the Beckman pH meter, using 50 grams of air-dry soil wetted to saturation and contained in a tall 4-ounce bottle. The readings were made after allowing the wet soil to stand a few hours. Carbonates were determined on all of the soils above pH 7.0. These were made by the McMillar method in which the soil is treated with standard hydrochloric acid until effervescence ceases and the quantity of acid used in the reaction is determined by back titration with a standard base. The quantity of acid used is assumed to be equivalent to the quantity of calcium carbonate present in the soil. It is recognized that this method involves certain errors, particularly where sodium carbonate is present, and the total carbonate is calculated as calcium, or lime, carbonate.

TABLE 9.—*Mechanical analyses of several soils from the Sacramento Area, California*

Soil and sample No.	Depth	Total sands (2.00 mm.–0.050 mm.)	Coarse silt (0.050–0.005 mm.)	Fine silt (0.005–0.002 mm.)	Clay (<0.002 mm.)	Colloidal clay (<0.001 mm.)
Auburn stony loam, rolling and hilly:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
5798–16	0– 5	45. 1	29. 9	9. 2	14. 7	9. 8
5798–17	5–11	41. 0	29. 9	10. 4	18. 3	13. 3
5798–18	11–20	21. 6	19. 7	8. 5	50. 2	44. 1
Redding gravelly loam, undulating and rolling:						
5798–35	0– 8	47. 9	30. 6	5. 4	16. 1	13. 1
5798–36	8–19	40. 8	19. 5	14. 0	25. 5	22. 5
5798–37	19–26	27. 8	18. 4	4. 5	50. 1	47. 6
5798–38	26–32	33. 6	15. 3	3. 8	47. 6	44. 9
5798–39	32–46	55. 5	15. 7	7. 5	22. 5	18. 1
5798–40	46–64	58. 7	12. 2	5. 4	24. 8	20. 3
Hanford very fine sandy loam, nearly level:						
5798–58	0–15	57. 0	26. 8	5. 7	10. 9	9. 4
5798–59	15–47	56. 5	27. 3	4. 7	12. 2	9. 2
5798–60	47–77	73. 8	14. 8	2. 9	9. 0	6. 5
Pentz sandy loam, rolling and hilly:						
5798–61	0– 9	69. 6	16. 6	2. 3	11. 8	9. 9
5798–62	2–23	69. 3	15. 1	3. 2	12. 7	11. 1
San Joaquin loam, very gently undulating:						
5798–73	1– 8	32. 6	45. 9	6. 8	13. 5	10. 1
5798–74	8–20	31. 7	44. 2	6. 8	16. 9	13. 9
5798–75	20–27	21. 6	33. 7	6. 1	39. 6	34. 3
Columbia fine sandy loam, nearly level:						
5798–91	1–10	67. 0	23. 3	4. 2	6. 0	4. 3
5798–92	10–46	70. 4	19. 5	3. 4	6. 4	5. 5
5798–93	46–66	72. 2	17. 4	3. 8	8. 3	7. 1

TABLE 10.—*Moisture equivalent, carbonates, and pH value of soils from the Sacramento Area, California*

Soil type and sample No.	Depth	Moisture equivalent	Calcium carbonate equivalent	pH
San Joaquin sandy loam, very gently undulating:	*Inches*	*Percent*	*Percent*	
5798–01	0–6	12. 7		5. 8
5798–02	6–22	13. 7		5. 9
5798–03	22–29	21. 3		6. 5
5798–04	29–39	13. 5	0. 6	7. 3
5798–05	39–57	14. 1	. 4	7. 5
Whitney fine sandy loam, rolling and hilly:				
5798–06	0–17	12. 1		5. 9
5798–07	17–29	15. 4		6. 1
5798–08	29–35	28. 7		6. 2
5798–09	35–42			5. 2
Siskiyou sandy loam, rolling and hilly:				
5798–10	0–8	13. 0		5. 9
5798–11	8–19	10. 9		5. 7
5798–12	19–27			4. 8
Holland sandy loam, rolling and hilly:				
5798–13	0–13	14. 8		6. 2
5798–14	13–27	13. 4		5. 8
5798–15	27–33			4. 9
Auburn stony loam, rolling and hilly:				
5798–16	0–5	20. 8		6. 3
5798–17	5–11	19. 5		6. 1
5798–18	11–20	36. 7		5. 9
5798–19	20–24			6. 0
Whiterock stony loam, rolling and hilly:				
5798–20	0–3	22. 6		4. 8
5798–21	3–10	20. 9		4. 9
5798–22	10–15			5. 0
Honcut loam, nearly level:				
5798–23	0–10	16. 9		5. 9
5798–24	10–30	16. 1		6. 5
5798–25	30–50	16. 7		6. 4
5798–26	50–75	14. 5		6. 9
Perkins gravelly loam, very gently undulating:				
5798–27	0–9	18. 6		5. 9
5798–28	9–19	18. 4		5. 7
5798–29	19–46	24. 1		6. 0
5798–30	46–72	22. 7		6. 1
Corning gravelly loam, undulating:				
5798–31	0–9	20. 4		5. 9
5798–32	9–27	19. 0		6. 6
5798–33	27–57	22. 3		7. 0
5798–34	57–80	26. 5		5. 8
Redding gravelly loam, undulating and rolling:				
5798–35	0–8	15. 2		5. 3
5798–36	8–19	16. 4		5. 2
5798–37	19–26	28. 5		5. 2
5798–38	26–32			4. 5
5798–39	32–46			5. 0
5798–40	46–64			5. 5
Ayar clay loam, rolling and hilly:				
5798–41	0–9	26. 9	21. 7	7. 6
5798–42	9–22	27. 6	28. 8	7. 8
5798–43	22–36		87. 8	7. 6

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TABLE 10.—*Moisture equivalent, carbonates, and pH value of soils from the Sacramento Area, California*—Continued

Soil type and sample No.	Depth	Moisture equivalent	Calcium carbonate equivalent	pH
Peters clay (adobe), rolling and hilly:	*Inches*	*Percent*	*Percent*	
5798-44	0-12	42. 1		5. 5
5798-45	12-32	46. 5		5. 4
5798-46	32-46			6. 8
Dorado stony silt loam, rolling and hilly:				
5798-47	0- 5	22. 9		5. 7
5798-48	5-14	21. 8		5. 8
5798-49	14-18	30. 8		5. 8
5798-50	18-25			5. 1
5798-51	25-36		3. 2	7. 7
Amador fine sandy loam, rolling and hilly:				
5798-52	0- 6	12. 4		5. 6
5798-53	6-19	11. 5		5. 4
5798-54	19-20	33. 5		4. 7
5798-55	20-26	16. 4		4. 7
Rydberg loam, very gently sloping:				
5798-56	0-18	19. 4		5. 8
5798-57	18-37	12. 0		5. 4
Hanford very fine sandy loam, nearly level:				
5798-58	0-15	20. 5		6. 4
5798-59	15-47	21. 4		6. 7
5798-60	47-77	14. 2		7. 0
Pentz sandy loam, rolling and hilly:				
5798-61	0- 9	13. 6		6. 3
5798-62	9-23	15. 0		6. 4
5798-63	23-36			6. 3
Bear Creek gravelly loam, very gently sloping:				
5798-64	0- 8	17. 0		6. 2
5798-65	8-25	13. 7		5. 6
5798-66	25-36			5. 5
Honcut gravelly loam, nearly level:				
5798-67	0- 9	17. 9		6. 2
5798-68	9-31	17. 3		6. 8
5798-69	31-56	17. 8		6. 8
San Joaquin loam, very gently undulating:				
5798-73	0- 8	17. 7		5. 5
5798-74	8-20	17. 3		5. 7
5798-75	20-27	27. 3		6. 2
5798-76	27-34		1. 2	7. 7
5798-77	34-46		5. 7	8. 0
Oakley sand, undulating:				
5798-82	0-15	3. 7		6. 7
5798-83	15-38	3. 5		6. 9
5798-84	38-70	3. 0		6. 9
Burns silty clay loam, nearly level:				
5798-85	0-15	54. 5		5. 9
5798-86	15-25	78. 5		5. 8
5798-87	25-38	81. 0		6. 1
Sacramento silty clay loam, nearly level:				
5798-88	0-14	48. 3	. 8	7. 2
5798-89	14-32	41. 5	2. 0	8. 2
5798-90	32-60	40. 3	4. 2	8. 3
Columbia fine sandy loam, nearly level:				
5798-91	0-10	20. 5		6. 1
5798-92	10-46	12. 8		6. 2
5798-93	46-66	16. 3	. 6	7. 1

TABLE 10.—*Moisture equivalent, carbonates, and pH value of soils from the Sacramento Area, California*—Continued

Soil type and sample No.	Depth	Moisture equivalent	Calcium carbonate equivalent	pH
	Inches	*Percent*	*Percent*	
Hanford loamy fine sand, nearly level:				
5798–94	0–24	10. 6	----------	6. 8
5798–95	24–66	8. 6	----------	6. 8
Glann loam, nearly level:				
5798–96	0– 4	29. 2	----------	5. 8
5798–97	4–20	14. 9	----------	6. 5
5798–98	20–30	17. 6	1. 0	8. 4
5798–99	30–46	[1] 40. 0	. 8	8. 7
5798–100	46–70	22. 9	. 6	8. 0
Alamo clay (adobe), nearly level:				
5798–105	0– 8	25. 4	----------	6. 0
5798–106	8–22	25. 5	----------	6. 4
5798–107	22–32	30. 2	4. 6	8. 1
5798–108	32–44	----------	22. 1	8. 4
Chualar gritty loam, very gently sloping:				
5798–109	0–18	15. 1	----------	6. 7
5798–110	18–38	18. 8	----------	6. 3
5798–111	38–54	17. 6	----------	6. 4

[1] Water standing on soil surface after standard centrifuging. Moisture equivalent as determined on re-run with waxed paper lining centrifuge cups.

On most of the upland soils, erosion is balanced by the soil-forming processes, so that there is always a mantle of soil on the parent rock. These upland soils show only a slight profile development, as indicated by the relatively uniform moisture equivalent values at different depths in a given soil profile. Although there are higher moisture-equivalent values for the subsoils of both Whitney fine sandy loam, rolling and hilly, and Amador fine sandy loam, rolling and hilly, the finer texture is due to the weathering of a clayey bedrock rather than to illuviation, as has been pointed out in the body of the report. However, illuviation seems to account for the increase in clay in the subsoil of Auburn stony loam, rolling and hilly. This soil is developed from a relatively uniform parent material, and both the moisture equivalents and the complete mechanical analysis of the profile indicate clay concentration in the subsoil. This soil is one of the deeper examples of the Auburn soils, with more profile development than is characteristic of the series as a whole.

The soils developed from recent and young alluvial deposits do not show any profile development, either in the data of moisture equivalents or of mechanical analyses. Hanford very fine sandy loam, nearly level, and Hanford loamy fine sand, nearly level, show a decrease in clay content with increased depth. This decrease is due to stratification of materials deposited by streams.

The soils developed on old alluvial plains and terraces are characterized by increased clay in the subsoils. This is borne out by increased moisture equivalent values in the B horizons and an increased clay content with depth. In the hardpan soils, the moisture equivalent increases with depth until the hardpan layer is reached, at which point the water-holding capacity decreases. The clays of this hardpan

layer have been cemented together and do not redisperse on wetting. In this respect they no longer act as clay particles but as rocklike or consolidated material. In order to determine the moisture equivalent, hardpan samples had to be ground with a mortar and pestle, so the values do not represent field water-holding capacities and are much higher due to the physical breaking apart of many cemented aggregates. The lower subsoil sample of Glann loam, nearly level (30 to 46 inches in depth), packed so tightly in the moisture equivalent cup during the running of the centrifuge that the water was unable to pass through the soil. The determination was repeated using waxed-paper linings in the cup to facilitate drainage. This latter figure probably approximates the field moisture-holding capacity.

Complete mechanical analyses were run on samples from two of the soils in this group, San Joaquin loam, very gently undulating and Redding gravelly loam, undulating and rolling. Both of these soils show a high proportion of colloidal clay with respect to total clay in the subsoils. A high content of colloidal clay usually correlates with sticky soils that break into hard aggregates. Although mechanical analyses were made on the hardpan layers of the Redding soil, it should be borne in mind that the samples were mechanically ground to pass through a 2-millimeter sieve, and the resulting analyses consequently do not give the same size distribution of particles as occurs in the soil in place.

The two alluvial basin soils analyzed are high in clay content as well as in water-holding capacity. These are Sacramento silty clay loam, nearly level, and Burns silty clay loam, nearly level. The surface soils have the highest moisture-equivalent values of any surface soils analyzed in the Sacramento Area. This high water-holding capacity is due to high organic-matter content as well as to high clay content. The subsoil of Burns silty clay loam, nearly level, is even higher in organic matter, and has a moisture-equivalent value of 81 percent. It is likely that in the natural state this subsoil has an even higher water-holding capacity, because once thoroughly dried out (as it is on being brought into the laboratory) it will not take up as much water as it would before drying out so completely. In the field, these subsoils are usually moist throughout the year.

The pH values reflect the climate of the region, the parent material, and the topography. In the upland region, the soils formed from hard bedrock are medium to strongly acid, generally being less acid in the surface layer than in the subsoils. The lowest sample from Dorado stony silt loam, rolling and hilly, is of the lower bedrock and has a basic reaction and a small quantity of lime; the soil, however, is medium acid. The soils from softly consolidated bedrock are somewhat less acid and are more uniform in pH value throughout their profiles. Ayar clay loam, rolling and hilly, is formed from marly shale and is high in lime. The lime apparently is gradually being leached out of the profile, for the surface soil contains 21.7 percent lime, whereas the soft shale contains 87.8 percent.

The soils of the recent alluvial flood plains are in general slightly acid, having been derived from medium acid upland materials. These soils have not developed in place long enough to have established a distinct pedologic pH pattern. Drainage downward is sufficiently restricted in the hardpan soils of the old alluvial plains and terraces so that the bases have not been completely leached out, and consequently

the subsoils are basic and frequently contain traces of lime. The peaty soils in the alluvial basin area tend to be slightly acid due to the high organic-matter content, as indicated by pH values for Burns silty clay loam, nearly level. Sacramento silty clay loam, nearly level, is neutral in reaction in the surface soil but has appreciable lime in the subsoil.

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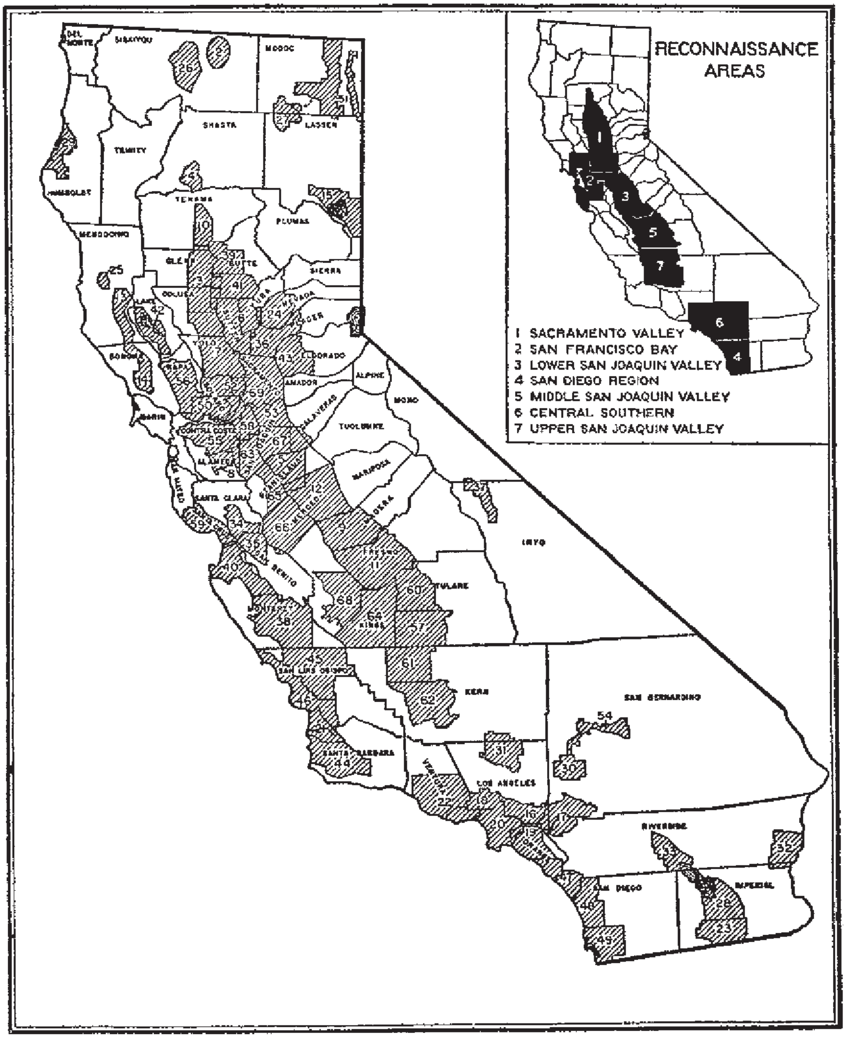

Areas surveyed in California shown by shading.

1. Sacramento
2. Butte Valley
3. Colusa
4. Redding
5. Modesto-Turlock
6. Marysville
7. Woodland
8. Livermore
9. Madera
10. Red Bluff
11. Fresno
12. Merced
13. Ukiah
14. Healdsburg
15. Honey Lake
16. Pasadena
17. Riverside
18. San Fernando Valley
19. Anaheim
20. Los Angeles
21. Santa Maria
22. Ventura
23. El Centro
24. Grass Valley
25. Willits
26. Shasta Valley
27. Big Valley
28. Brawley
29. Eureka
30. Victorville
31. Lancaster
32. Palo Verde
33. Coachella Valley
34. Gilroy
35. Hollister
36. Auburn
37. Bishop
38. King City
39. Chico
40. Salinas
41. Oroville
42. Clear Lake
43. Placerville
44. Santa Ynez
45. Paso Robles
46. San Luis Obispo
47. Capistrano
48. Oceanside
49. El Cajon
50. Suisun
51. Alturas
52. Dixon
53. Lodi
54. Barstow County
55. Contra Costa
56. Napa
57. Pixley
58. Sacramento-San Joaquin Delta
59. Santa Cruz
60. Visalia
61. Wasco
62. Bakersfield
63. Tracy
64. Kings County
65. Newman
66. Los Banos
67. Stockton

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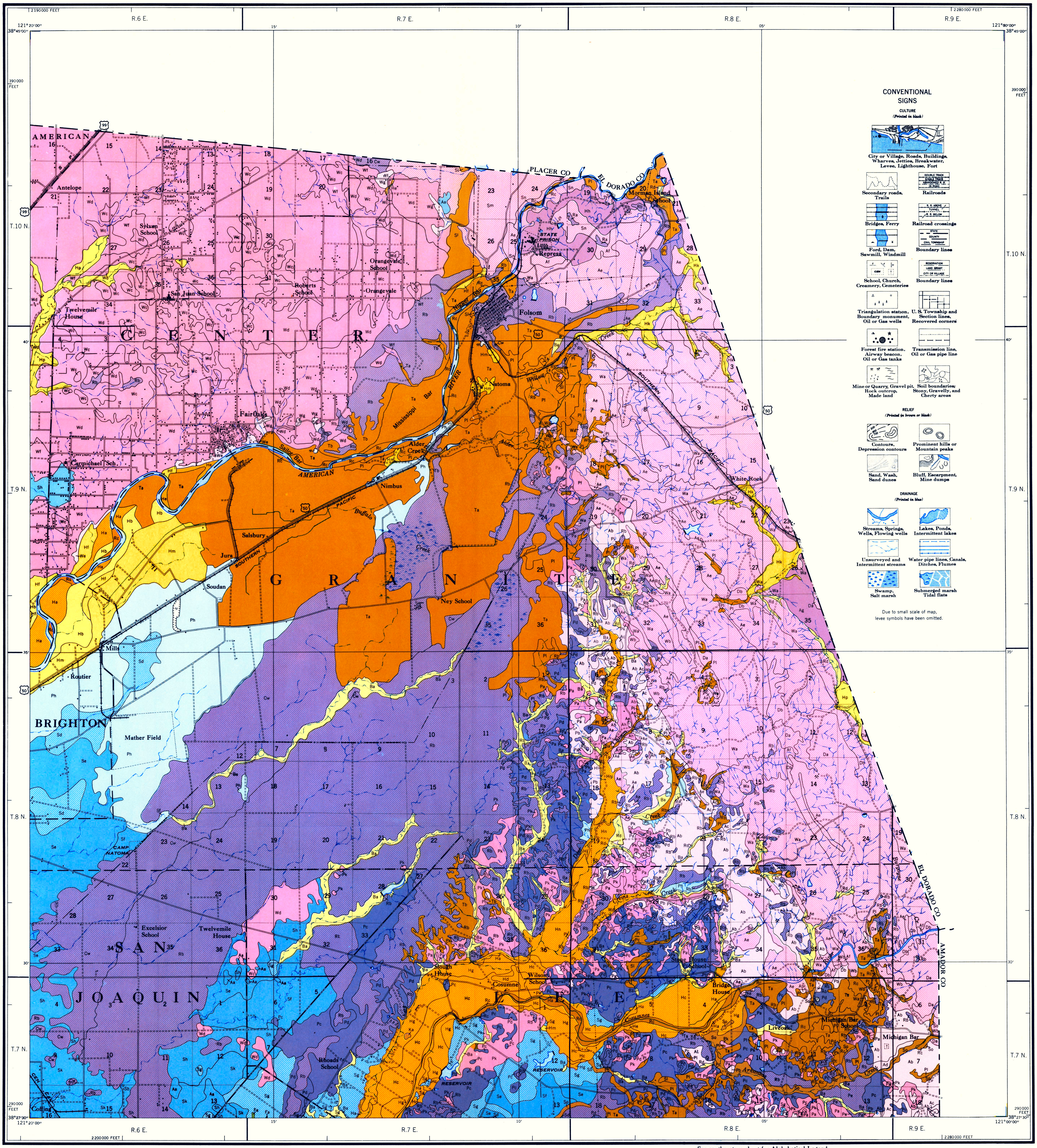
SOIL MAP

SACRAMENTO AREA - CALIFORNIA

NORTHEASTERN SHEET

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION



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R. C. Roberts, Principal Soil Correlator, Far Western States.
Correlation and inspection by R. A. Gardner, Senior Soil Correlator.
Soils surveyed 1940-41 by Ralph C. Cole, in charge, and L. K. Stromberg, University of California, and O. F. Bartholomew and John L. Retzer, U. S. Department of Agriculture.

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1 ½ 0 1 2 Miles

5000 0 5000 10000 Feet

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Soil survey on USGS topographical quadrangles and aerial photographs.
Polyconic projection, 1927 North American datum.
10,000 foot grid based on California (Zone II) rectangular coordinate system.

U. S. DEPARTMENT OF AGRICULTURE
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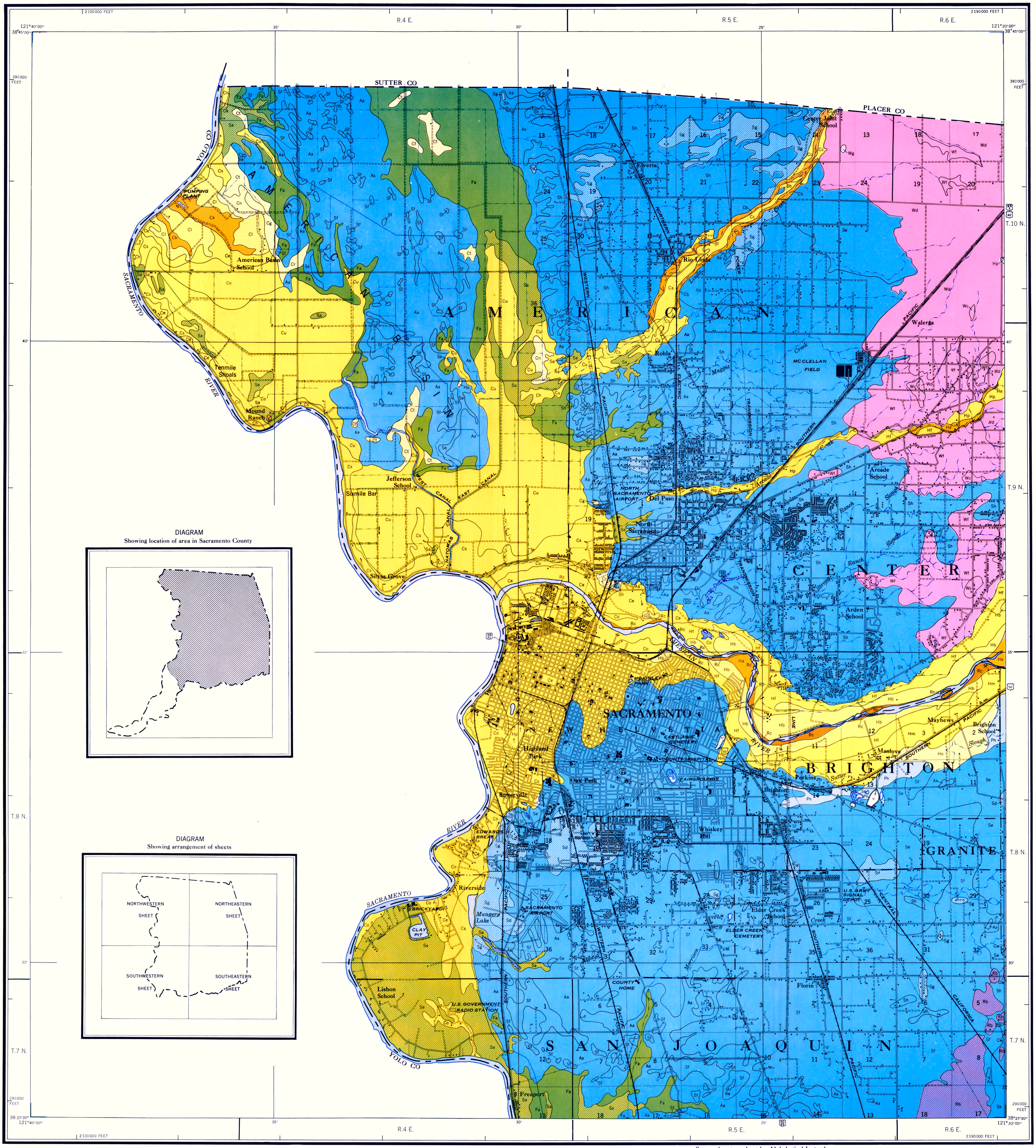
SOIL MAP

SACRAMENTO AREA - CALIFORNIA

NORTHWESTERN SHEET

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION



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1 ½ 0 1 2 Miles

5000 0 5000 10000 Feet

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SOIL CONSERVATION SERVICE

SOIL MAP

SACRAMENTO AREA - CALIFORNIA

SOUTHEASTERN SHEET

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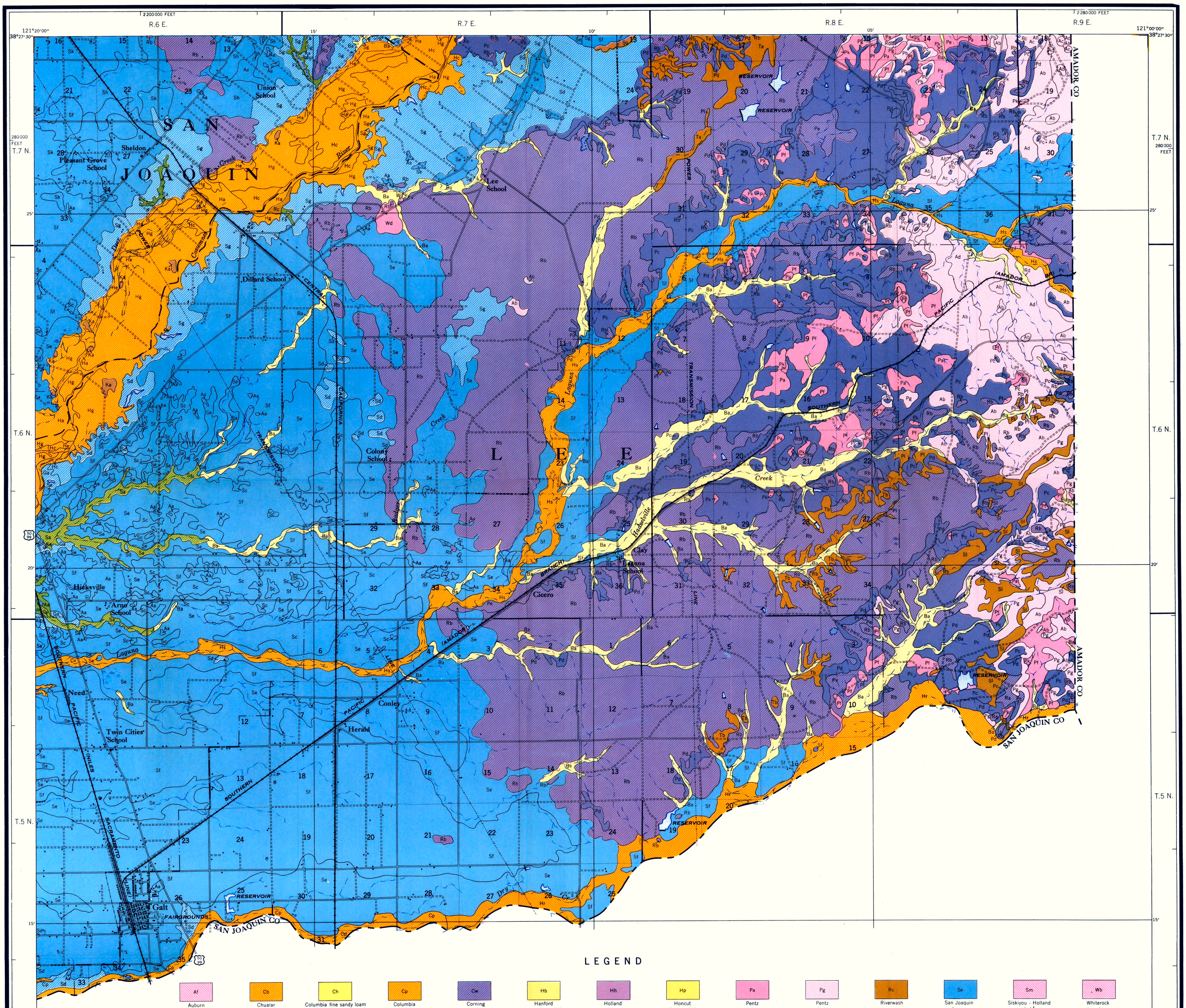

LEGEND

- **Aa** — Alamo clay (adobe), nearly level (0-1 percent slope)
- **Ab** — Amador fine sandy loam, rolling and hilly (8-25 percent slope)
- **Ac** — Amador fine sandy loam, steep (25+ percent slope)
- **Ad** — Amador fine sandy loam, undulating (3-8 percent slope)
- **Ae** — Auburn stony loam, rolling and hilly (8-25 percent slope)
- **Af** — Auburn stony loam, steep (25+ percent slope)
- **Ag** — Auburn stony loam, undulating (3-8 percent slope)
- **Ah** — Ayar clay loam, rolling and hilly (8-25 percent slope)
- **Ba** — Bear Creek gravelly loam, very gently sloping (0-3 percent slope)
- **Bb** — Burns silty clay loam, nearly level (0-1 percent slope)
- **Ca** — Chualar gritty clay loam, nearly level (0-1 percent slope)
- **Cb** — Chualar gritty loam, channeled, very gently sloping (0-3 percent slope)
- **Cc** — Chualar gritty loam, very gently sloping (0-2 percent slope)
- **Cd** — Columbia fine sandy loam, channeled, nearly level (0-1 percent slope)
- **Ce** — Columbia fine sandy loam, nearly level (0-1 percent slope)
- **Cf** — Columbia fine sandy loam, overflowed, nearly level (0-1 percent slope)
- **Cg** — Columbia fine sandy loam (over Freeport clay) nearly level (0-1 percent slope)
- **Ch** — Columbia fine sandy loam (over Sacramento silty clay loam), nearly level (0-1 percent slope)
- **Ck** — Columbia loamy fine sand, channeled, nearly level (0-1 percent slope)
- **Cl** — Columbia loamy fine sand, nearly level (0-1 percent slope)
- **Cm** — Columbia loamy fine sand, overflowed, nearly level (0-1 percent slope)
- **Cn** — Columbia loamy fine sand (over Freeport clay), nearly level (0-1 percent slope)
- **Co** — Columbia silt loam, nearly level (0-1 percent slope)
- **Cp** — Columbia silt loam, overflowed, nearly level (0-1 percent slope)
- **Cr** — Columbia silt loam (over Freeport clay), nearly level (0-1 percent slope)
- **Cs** — Columbia silt loam (over Sacramento silty clay loam), nearly level (0-1 percent slope)
- **Ct** — Columbia silty clay (over Freeport clay), nearly level (0-1 percent slope)
- **Cu** — Columbia silty clay (over Sacramento silty clay), nearly level (0-1 percent slope)
- **Cv** — Columbia silty clay (over Sacramento silty clay), overflowed, nearly level (0-1 percent slope)
- **Cw** — Corning gravelly loam, undulating (3-8 percent slope
- **Da** — Dorado stony silt loam, rolling and hilly (8-25 percent slope)
- **Db** — Dorado stony silt loam, steep (25+ percent slope)
- **Fa** — Freeport clay (adobe), nearly level (0-1 percent slope)
- **Ga** — Glann loam, nearly level (0-1 percent slope)
- **Ha** — Hanford loamy fine sand, channeled, nearly level (0-1 percent slope)
- **Hb** — Hanford loamy fine sand, nearly level (0-1 percent slope)
- **Hc** — Hanford loamy fine sand, overflowed, nearly level (0-1 percent slope)
- **Hd** — Hanford sand, overflowed, nearly level (0-1 percent slope)
- **He** — Hanford very fine sandy loam, channeled, nearly level (0-1 percent slope)
- **Hf** — Hanford very fine sandy loam, nearly level (0-1 percent slope)
- **Hg** — Hanford very fine sandy loam, overflowed, nearly level (0-1 percent slope)
- **Hh** — Holland sandy loam, rolling and hilly (8-25 percent slope)
- **Hk** — Honcut gravelly loam, nearly level (0-1 percent slope)
- **Hl** — Honcut loam, channeled, nearly level (0-1 percent slope)
- **Hm** — Honcut loam, nearly level (0-1 percent slope)
- **Hn** — Honcut loam, overflowed, nearly level (0-1 percent slope)
- **Ho** — Honcut loam (over San Joaquin hardpan substratum), nearly level (0-1 percent slope)
- **Hp** — Honcut very fine sandy loam, nearly level (0-1 percent slope)
- **Hr** — Honcut very fine sandy loam, overflowed, nearly level (0-1 percent slope)
- **Hs** — Honcut very fine sandy loam (over Bear Creek gravelly loam), overflowed, very gently sloping (0-3 percent slope)
- **Ka** — Kitchen middens
- **Oa** — Oakley loamy fine sand (over Glann loam), undulating (3-8 percent slope)
- **Ob** — Oakley sand, undulating (3-8 percent slope)
- **Pa** — Pentz loam, rolling and hilly (8-25 percent slope)
- **Pb** — Pentz loam, steep (25+ percent slope)
- **Pc** — Pentz - Redding gravelly loams, rolling and hilly (8-25 percent slopes)
- **Pd** — Pentz - Redding gravelly loams, steep (25+ percent slopes)
- **Pe** — Pentz - Redding gravelly loams, undulating 3-8 percent slopes)
- **Pf** — Pentz sandy loam, rolling and hilly (8-25 percent slope)
- **Pg** — Pentz sandy loam, steep (25+ percent slope)
- **Ph** — Perkins gravelly loam, very gently undulating (0-3 percent slope)
- **Pk** — Peters clay (adobe), rolling and hilly (8-25 percent slope)
- **Pl** — Placer diggings
- **Ra** — Redding cobbly loam, undulating (3-8 percent slope)
- **Rb** — Redding gravelly loam, undulating and rolling (2-15 percent slope)
- **Rc** — Riverwash
- **Rd** — Rydberg loam, very gently sloping (0-3 percent slope)
- **Sa** — Sacramento silty clay loam, nearly level (0-1 percent slope)
- **Sb** — Sacramento silty clay loam, overflowed, nearly level (0-1 percent slope)
- **Sc** — San Joaquin loam - Alamo clay (adobe), very gently undulating (0-3 percent slope)
- **Sd** — San Joaquin loam, deep, undulating (3-8 percent slope)
- **Se** — San Joaquin loam, undulating (3-8 percent slope)
- **Sf** — San Joaquin loam, very gently undulating (0-3 percent slope)
- **Sg** — San Joaquin sandy loam, deep, undulating (3-8 percent slope)
- **Sh** — San Joaquin sandy loam, undulating (3-8 percent slope)
- **Sk** — San Joaquin sandy loam, very gently undulating (0-3 percent slope)
- **Sl** — Scabland
- **Sm** — Siskiyou - Holland sandy loams, rolling and hilly (8-25 percent slopes)
- **Sn** — Siskiyou - Holland sandy loams, stony and steep (25+ percent slopes)
- **So** — Slickens
- **Ta** — Tailings
- **Tb** — Terrace breaks, Redding - Corning soil materials, steep (25+ percent slopes)
- **Wa** — Whiterock stony loam, rolling and hilly (8-25 percent slope)
- **Wb** — Whiterock stony loam, steep (25+ percent slope)
- **Wc** — Whitney fine sandy loam, deep, undulating and rolling (3-15 percent slope)
- **Wd** — Whitney fine sandy loam, rolling and hilly (8-25 percent slope)
- **We** — Whitney fine sandy loam, steep (25+ percent slope)
- **Wf** — Whitney fine sandy loam, undulating (3-8 percent slope)
- **Wg** — Whitney gravelly sandy loam, rolling (8-15 percent slope)

38°10'00" 121°20'00" — R.6 E. — 2 200 000 FEET — 15' — R.7 E. — 10' — R.8 E. — 05' — 2 280 000 FEET — 38°10'00" 121°00'00"

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Scale 1:63,360

1 ½ 0 1 2 Miles

5000 0 5000 10000 Feet

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See southwestern sheet for Color Grouping, and northeastern sheet for Conventional Signs.

Base map compiled by the Cartographic Division, Soil Conservation Service, USDA, from USGS and USCE topographical quadrangles and 1937 aerial photographs.
Soil survey on USGS topographical quadrangles and aerial photographs.
Polyconic projection, 1927 North American datum.
10,000 foot grid based on California (Zone II) rectangular coordinate system.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MAP

SACRAMENTO AREA - CALIFORNIA

SOUTHWESTERN SHEET

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION

COLOR GROUPING

UPLAND SOILS DEVELOPED ON CONSOLIDATED BEDROCK

MODERATELY DEEP SOILS UNDERLAIN BY HARD BEDROCK

Auburn stony loam, undulating
Holland sandy loam, rolling and hilly

SHALLOW SOILS UNDERLAIN BY HARD BEDROCK

Auburn stony loam, rolling and hilly
Auburn stony loam, steep
Dorado stony silt loam, rolling and hilly
Dorado stony silt loam, steep
Siskiyou - Holland sandy loams, rolling and hilly
Siskiyou - Holland sandy loams, stony and steep
Whiterock stony loam, rolling and hilly
Whiterock stony loam, steep

UNDULATING, ROLLING, OR HILLY, MODERATELY DEEP SOILS UNDERLAIN BY SOFTLY CONSOLIDATED SEDIMENTARY BEDROCK

Ayar clay loam, rolling and hilly
Pentz sandy loam, rolling and hilly
Pentz loam, rolling and hilly
Peters clay (adobe), rolling and hilly
Whitney fine sandy loam, rolling and hilly
Whitney fine sandy loam, undulating
Whitney fine sandy loam, deep, undulating and rolling

STEEP OR SHALLOW SOILS UNDERLAIN BY SOFTLY CONSOLIDATED SEDIMENTARY BEDROCK

Amador fine sandy loam, rolling and hilly
Amador fine sandy loam, undulating
Amador fine sandy loam, steep
Pentz sandy loam, steep
Pentz loam, steep
Whitney fine sandy loam, steep
Whitney gravelly sandy loam, rolling

SOILS DEVELOPED ON RECENT AND YOUNG FLOOD PLAINS AND ALLUVIAL FANS

DEEP, FINE TO MODERATELY COARSE-TEXTURED SOILS SUBJECT TO INFREQUENT OVERFLOW

Chualar gritty loam, very gently sloping
Chualar gritty clay loam, nearly level
Columbia fine sandy loam, nearly level
Columbia fine sandy loam (over Sacramento silty clay loam), nearly level
Columbia silt loam, nearly level
Columbia silt loam (over Sacramento silty clay loam), nearly level
Columbia silty clay (over Sacramento silty clay), nearly level
Hanford very fine sandy loam, nearly level
Honcut very fine sandy loam, nearly level
Honcut loam, nearly level
Honcut gravelly loam, nearly level

SHALLOW TO MODERATELY DEEP, FINE TO COARSE-TEXTURED SOILS, SUBJECT TO INFREQUENT OVERFLOW

Bear Creek gravelly loam, very gently sloping
Columbia loamy fine sand (over Freeport clay), nearly level
Columbia fine sandy loam (over Freeport clay), nearly level
Columbia silt loam (over Freeport clay), nearly level
Columbia silty clay (over Freeport clay), nearly level
Honcut loam (over San Joaquin hardpan substratum), nearly level
Rydberg loam, very gently sloping

DEEP OR MODERATELY DEEP, COARSE-TEXTURED SOILS, SUBJECT TO INFREQUENT OVERFLOW

Columbia loamy fine sand, nearly level
Hanford loamy fine sand, nearly level
Oakley sand, undulating
Oakley loamy fine sand, (over Glann loam), undulating

SOILS SUBJECT TO PERIODIC OVERFLOW

Chualar gritty loam, channeled, very gently sloping
Columbia fine sandy loam, channeled, nearly level
Columbia fine sandy loam, overflowed, nearly level
Columbia loamy fine sand, channeled, nearly level
Columbia loamy fine sand, overflowed, nearly level
Columbia silt loam, overflowed, nearly level
Columbia silty clay (over Sacramento silty clay), overflowed, nearly level
Hanford very fine sandy loam, channeled, nearly level
Hanford very fine sandy loam, overflowed, nearly level
Hanford loamy fine sand, channeled, nearly level
Hanford loamy fine sand, overflowed, nearly level
Hanford sand, overflowed, nearly level
Honcut loam, channeled, nearly level
Honcut loam, overflowed, nearly level
Honcut very fine sandy loam, overflowed, nearly level
Honcut very fine sandy loam (over Bear Creek gravelly loam), overflowed, very gently sloping
Sacramento silty clay loam, overflowed, nearly level

SOILS DEVELOPED ON OLD ALLUVIAL PLAINS AND TERRACES

UNDULATING AND ROLLING SOILS DEVELOPED ON HIGHER TERRACES AND UNDERLAIN BY CLAYPAN OR HARDPAN

Corning gravelly loam, undulating
Pentz - Redding gravelly loams, undulating
Redding gravelly loam, undulating and rolling
Redding cobbly loam, undulating

ROLLING AND STEEP SOILS DEVELOPED ON HIGHER TERRACES AND UNDERLAIN BY CLAYPAN OR HARDPAN

Pentz - Redding gravelly loams, rolling and nilly
Pentz - Redding gravelly loams, steep

SHALLOW SOILS DEVELOPED ON LOWER TERRACES AND OLD ALLUVIAL PLAINS AND UNDERLAIN BY CLAYPAN, HARDPAN, AND SEMICONSOLIDATED SUBSTRATA

Alamo clay (adobe), nearly level
San Joaquin sandy loam, very gently undulating
San Joaquin sandy loam, undulating
San Joaquin loam, very gently undulating
San Joaquin loam, undulating
San Joaquin loam - Alamo clay (adobe), very gently undulating

MODERATELY DEEP SOILS DEVELOPED ON LOWER TERRACES AND OLD ALLUVIAL PLAINS AND UNDERLAIN BY CLAYPAN, HARDPAN, OR SEMICONSOLIDATED SUBSTRATA

Glann loam, nearly level
San Joaquin sandy loam, deep, undulating
San Joaquin loam, deep, undulating

DEEP SOILS DEVELOPED ON LOWER TERRACES AND OLD ALLUVIAL PLAINS

Perkins gravelly loam, very gently undulating

SOILS DEVELOPED IN ALLUVIAL BASINS

MODERATELY FINE-TEXTURED SOILS

Sacramento silty clay loam, nearly level

FINE-TEXTURED SOILS

Freeport clay (adobe), nearly level

HIGHLY ORGANIC SOILS

Burns silty clay loam, nearly level

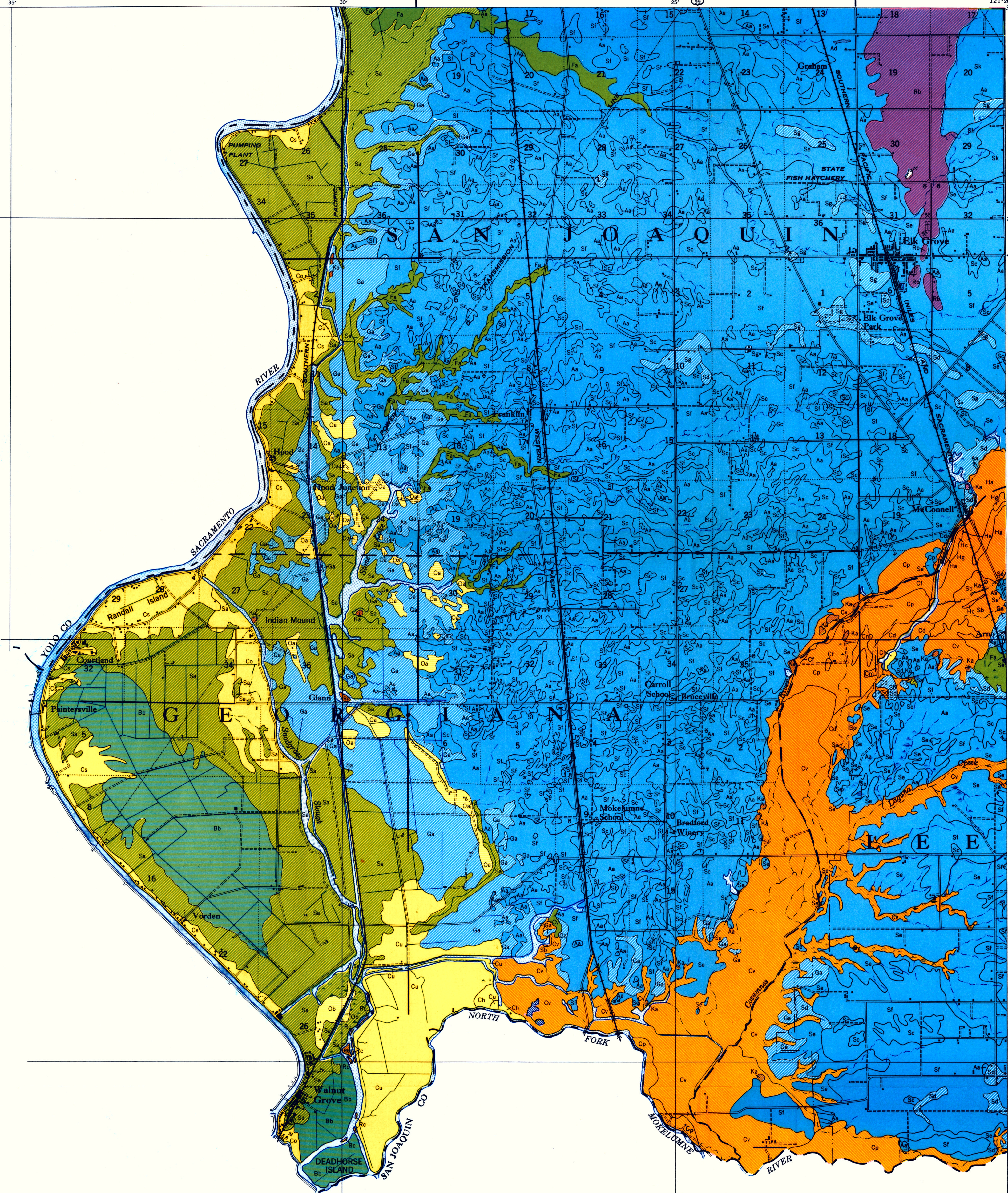
MISCELLANEOUS LAND TYPES

MISCELLANEOUS LAND TYPES OF SOME AGRICULTURAL USE

Kitchen middens
Slickens

MISCELLANEOUS LAND TYPES OF LITTLE OR NO AGRICULTURAL USE

Placer diggings
Riverwash
Scabland
Tailings
Terrace breaks (Redding - Corning soil materials), steep



38°10'00" 121°40'00" 35' 30' 25' 121°20'00" 38°10'00"

2100000 FEET 2190000 FEET

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Soils surveyed 1940-41 by Ralph C. Cole, in charge, and L. K. Stromberg, University of California, and O. F. Bartholomew and John L. Retzer, U. S. Department of Agriculture.

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See southeastern sheet for Alphabetical Legend, northeastern sheet for Conventional Signs.

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SACRAMENTO AREA, CALIFORNIA, SOILS: SUMMARY OF IMPORTANT CHARACTERISTICS

Soils	Map symbol	Slope range (percent)	Soil profile			Soil depth [1]	Permeability [2]		Surface runoff	Occurrence of high water table [3]	Available water-holding capacity [4]	Erosion hazard [5]	Natural fertility [6]	Workability [7]	Present use or vegetative cover
			Surface soil	Subsoil	Parent material or substratum		Surface soil	Subsoil or substratum							
Alamo clay (adobe), nearly level	Aa	0-1	Dark gray; slightly acid; coarse blocky.	Dark-gray to grayish-brown, compact, calcareous clay over calcareous hardpan.	Calcareous old semiconsolidated alluvium from mixed rocks.	Moderately shallow; variable.	Very slow	Very slow	Very slow; ponding.	None	Moderate	None	Moderate	Difficult	Grain or grain hay; pasture.
Amador fine sandy loam:															
Rolling and hilly	Ab	8-25	Very pale brown or light brownish gray; acid.	Acid fine sandy loam or loam similar in color and reaction to the surface soil.	Softly consolidated, light-colored sedimentary rock.	Shallow	Moderate	Moderate	Medium to rapid	do	Low	Moderate to high	Low	Relatively difficult	Annual grasses, scrub oak, and digger pine.
Steep	Ac	25+	do	Fine sandy loam or loam lighter in color than the surface soil.	do	Very shallow to shallow.	do	do	Very rapid	do	do	Very high	do	Very difficult	Brush, scrub oak, digger pine, grasses.
Undulating	Ad	3-8	do	Fine sandy loam or loam similar in color to the surface soil.	do	Shallow	do	do	Slow	do	do	Slight	do	Relatively difficult	Annual grasses, scrub oak, and digger pine.
Auburn stony loam:															
Rolling and hilly	Ae	8-25	Light reddish brown or yellowish red; acid.	Reddish-brown acid stony loam or stony clay loam.	Andesitic or metamorphosed igneous bedrock.	do	do	do	Medium to rapid	do	do	Moderate	Moderate	Difficult	Do.
Steep	Af	25+	do	do	do	do	do	do	Very rapid	do	do	High	do	Very difficult	Do.
Undulating	Ag	3-8	do	do	do	Moderately shallow	do	do	Slow to medium	do	do	Slight	do	Relatively difficult	Do.
Ayar clay loam, rolling and hilly	Ah	8-25	Brown or dark reddish-brown; friable; calcareous; granular.	Brown or reddish-brown; highly calcareous.	Light-colored highly calcareous shale bedrock.	do	do	do	Medium to rapid	do	Moderate	Moderate	do	do	Scattered oaks and annual grasses.
Bear Creek gravelly loam, very gently sloping.	Ba	0-3	Dark grayish brown or grayish brown; nearly neutral.	Grayish-brown or brown neutral gravelly loam; somewhat stratified.	Unrelated semiconsolidated old alluvium.	Moderately deep	do	do	Very slow	do	do	Negligible; overflow rare.	do	do	Annual grasses.
Burns silty clay loam, nearly level.	Bb	0-1	Dark grayish brown or dark gray, granular; neutral or slightly acid; highly organic.	Dark-brown or dark-gray, neutral organic material.	Fine-textured, mottled alluvial material from mixed rock sources.	Deep, if drained	Moderate, if drained.	Moderate, if drained.	Ponded unless drained.	Constant	High	None	High	Easy	Asparagus and other truck crops.
Chualar gritty clay loam, nearly level.	Ca	0-1	Dark grayish brown; neutral; firm or hard.	Grayish-brown to gray neutral somewhat compact gritty clay loam.	Grayish-brown slightly mottled alluvium from granitic rocks.	Deep	Moderate	Moderate	Very slow	Occasional	do	Negligible; occasional overflow.	Moderate	Relatively difficult	Grain, alfalfa, Ladino clover.
Chualar gritty loam:															
Channeled, very gently sloping.	Cb	0-3	Grayish brown to dark grayish brown; neutral.	Brown, neutral, somewhat compact sandy or gritty clay loam.	Grayish-brown slightly mottled alluvium from granitic rocks.	do	do	do	do	do	Moderate	Occasional overflow	do	do	Trees, willows, brush, grasses.
Very gently sloping	Cc	0-2	do	do	do	do	do	do	do	do	do	Negligible; rare overflow.	do	Easy	Orchard fruits, alfalfa, Ladino clover.
Columbia fine sandy loam:															
Channeled, nearly level	Cd	0-1	Pale brown or yellowish brown; neutral; friable.	Rust-brown mottled stratified sandy alluvial material.	Stratified sandy alluvium from mixed rock sources.	do	Rapid	Rapid	do	do	do	Periodic overflow	do	Relatively difficult	Oaks, cottonwoods; grasses.
Nearly level	Ce	0-1	do	do	do	do	do	do	do	do	do	None	High	Easy	Wide range of crops.
Overflowed, nearly level	Cf	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Pasture, field crops.
Columbia fine sandy loam (over Freeport clay), nearly level.	Cg	0-1	do	do	Unrelated dark-colored clay alluvium.	Moderately shallow to moderately deep.	do	Rapid in subsoil; very slow in substratum.	do	do	do	None	do	do	Field and truck crops.
Columbia fine sandy loam (over Sacramento silty clay loam), nearly level.	Ch	0-1	do	do	Dark-colored silty clay loam alluvium.	Deep	do	Slow	do	do	do	do	do	do	Wide range of crops.
Columbia loamy fine sand:															
Channeled, nearly level	Ck	0-1	Light yellowish brown or pale brown; neutral; very friable; massive.	do	Stratified sandy alluvium from mixed rock sources.	do	Very rapid	Very rapid	do	do	Low	Occasional overflow	Moderate	Relatively difficult	Cottonwoods; grasses.
Nearly level	Cl	0-1	do	do	do	do	do	do	do	do	do	None	do	Easy	Alfalfa, orchard fruits, other crops.
Overflowed, nearly level	Cm	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Pasture, field crops.
Columbia loamy fine sand (over Freeport clay), nearly level.	Cn	0-1	Pale brown; neutral; very friable.	do	Unrelated dark-colored clay alluvium.	Moderately deep	do	Very rapid in subsoil; very slow in substratum.	do	do	do	None	do	do	Alfalfa, truck, and orchard crops.
Columbia silt loam:															
Nearly level	Co	0-1	Light brown, pale brown, or yellowish brown; neutral; friable.	Similar colored, rust-brown mottled, stratified silty alluvial material.	Stratified silty alluvium from mixed rock sources.	Deep	Moderate	Moderate	do	do	High	do	High	do	Wide range of crops.
Overflowed, nearly level	Cp	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Pasture, hops, field crops.
Columbia silt loam (over Freeport clay), nearly level.	Cr	0-1	do	do	Unrelated dark-colored clay alluvium.	Moderately shallow to moderately deep.	do	Moderate in subsoil; very slow in substratum.	do	do	do	None	do	do	Field and truck crops.
Columbia silt loam (over Sacramento silty clay loam), nearly level.	Cs	0-1	do	do	Dark-colored silty clay loam alluvium.	Deep	do	Moderate in subsoil; slow in substratum.	do	do	do	do	do	do	Wide range of crops.
Columbia silty clay (over Freeport clay), nearly level.	Ct	0-1	Light brown, pale-brown, or yellowish brown; neutral; friable.	Rust-brown mottled, silty alluvial material.	Unrelated dark-colored clay alluvium.	Variable	Slow	Slow	do	do	do	do	do	Relatively difficult	Field and truck crops
Columbia silty clay (over Sacramento silty clay):															
Nearly level	Cu	0-1	Light brown, pale-brown, or light yellowish brown; friable.	do	Dark-colored silty clay alluvium.	Deep	do	Slow in subsoil; very slow in substratum.	do	do	do	do	do	do	Do.
Overflowed, nearly level	Cv	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Pasture, field crops.
Corning gravelly loam, undulating.	Cw	3-8	Reddish-brown; acid; hard when dry.	Red to reddish-brown, compact, acid gravelly clay.	Old gravelly alluvial terrace material.	Moderately shallow	Moderate	Very slow	Slow to medium	None	Low	Slight	Low	do	Dry-farmed grain; short annual grasses; pasture.
Dorado stony silt loam:															
Rolling and hilly	Da	8-25	Reddish-yellow or light reddish-brown; acid; granular.	Slightly redder, acid stony silt loam.	Slatelike schist	Shallow	do	Moderate	Medium to rapid	do	do	Moderate	do	Difficult	Annual grasses.
Steep	Db	25+	do	do	do	Very shallow	do	do	Very rapid	do	do	High	do	Very difficult	Do.
Freeport clay (adobe), nearly level.	Fa	0-1	Very dark-gray; blocky; neutral.	Dark-gray, mottled, compact clay; calcareous in lower part.	Mottled fine-textured basin alluvium from mixed rock sources.	Moderately deep	Slow	Very slow	Very slow	Frequent	High	None	Moderate	Difficult	Grain, rice, other field crops.
Glann loam, nearly level	Ga	0-1	Dark grayish-brown; friable; acid.	Gray or grayish-brown, compact, slightly acid sandy clay to clay.	Hardpanlike substratum of old alluvial material; variable in consolidation.	do	Moderate	do	do	do	Moderate	Occasional overflow	do	Easy	Ladino clover; truck crops, pasture.
Hanford loamy fine sand:															
Channeled, nearly level	Ha	0-1	Brown; neutral; loose	Lighter colored, neutral, stratified loamy fine sand to sand.	Stratified alluvium from granitic rock.	Deep	Very rapid	Very rapid	do	None	Low	Periodic overflow	Moderate	Relatively difficult.	Oaks, cottonwoods; grasses.
Nearly level	Hb	0-1	do	do	do	do	do	do	do	do	do	Occasional overflow	do	Easy	Wide range of crops.
Overflowed, nearly level	Hc	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Pasture, hops, field crops.
Hanford sand, overflowed, nearly level.	Hd	0-1	Brown; neutral; loose; single grained.	Light-brown or pale-brown, neutral, loose sand.	Coarse-textured alluvium from granitic rock.	do	do	do	do	do	Very low	Slight wind, periodic overflow.	Low	do	Field crops.
Hanford very fine sandy loam:															
Channeled, nearly level	He	0-1	Brown; friable; neutral	Lighter colored, neutral, slightly stratified, medium-textured material.	Slightly stratified alluvium from granitic rock.	do	Moderate	Moderate	Very slow	do	Moderate	Periodic overflow	High	Relatively difficult.	Oaks, cottonwoods; grasses.
Nearly level	Hf	0-1	do	do	do	do	do	do	do	do	do	Rare overflow	do	Easy	Wide range of crops.
Overflowed, nearly level	Hg	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Hops, alfalfa, orchard crops.
Holland sandy loam, rolling and hilly.	Hh	8-25	Brown or grayish brown; slightly acid; friable.	Brown, slightly acid, gritty, sandy loam or loam.	Crumbling granitic bedrock	Moderately deep	Rapid	Rapid to moderate	Medium to rapid	do	Low	Moderate to high	Low	Relatively difficult.	Orchard fruits, oaks, digger pines; grasses.
Honcut gravelly loam, nearly level.	Hk	0-1	Reddish brown or brown; slightly acid; friable.	Reddish-brown neutral friable gravelly loam.	Stratified gravelly alluvium mainly from basic igneous rock.	Deep	Moderate	Moderate	Very slow	do	Moderate	Rare overflow	Moderate	do	Dry-farmed grain; pasture; irrigation not developed.
Honcut loam:															
Channeled, nearly level	Hl	0-1	Brown or reddish brown; friable; slightly acid to neutral.	Brown or reddish-brown, friable, neutral loam.	Stratified alluvium mainly from basic igneous rock.	do	do	do	do	do	do	Periodic overflow	do	do	Cottonwoods, willows; grasses.
Nearly level	Hm	0-1	do	do	Slightly stratified alluvium mainly from basic igneous rock.	do	do	do	do	do	do	Rare overflow	do	Easy	Wide range of crops where irrigation is developed.
Overflowed, nearly level	Hn	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Pasture, dry-farmed grain.
Honcut loam (over San Joaquin hardpan substratum), nearly level.	Ho	0-1	do	do	Hardpan substratum similar to San Joaquin series.	Moderately deep	do	Moderate in subsoil; very slow in hardpan substratum.	do	do	do	Rare overflow	do	do	Wide range of crops.
Honcut very fine sandy loam:															
Nearly level	Hp	0-1	Brown or reddish brown; slightly acid; friable.	Slightly lighter colored nearly neutral, friable, medium-textured alluvium.	Slightly stratified alluvium mainly from basic igneous rock.	Deep	do	Moderate	do	do	Moderate	Occasional overflow	Moderate	do	Dry-farmed grain, pasture; irrigation not developed.
Overflowed, nearly level	Hr	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Do.
Honcut very fine sandy loam (over Bear Creek gravelly loam), overflowed, very gently sloping.	Hs	0-3	Pale-brown or yellowish brown; friable; somewhat variable texture.	Grayish-brown gravelly loam	Lighter colored, stratified, gravelly alluvium.	do	do	do	Very slow to slow	do	do	do	do	do	Do.
Kitchen middens	Ka	-------	Areas of Indian encampments. Generally composed of dark-colored, calcareous material containing ashes, charcoal, and fragments of shells and bones. In some places artifacts are found												In places cultivated with the surrounding soil.
Oakley loamy fine sand (over Glann loam), undulating.	Oa	3-8	Pale-brown or light-brownish-gray; neutral; very friable.	Grayish-brown, neutral, very friable, mottled loamy fine sand.	Unrelated grayish-brown or yellowish-brown clay loam or sandy clay loam.	Moderately deep	Very rapid	Very rapid in subsoil; slow to very slow in substratum.	Very slow	Occasional	Low	Negligible	Low	Easy	Field crops; pasture.
Oakley sand, undulating	Ob	3-8	Pale-brown or grayish-brown; loose; slightly acid.	Pale-brown or light yellowish-brown, loose; single grained, neutral sand.	Loose sand of alluvial origin considerably modified by wind.	Deep	do	Very rapid	do	None	Very low	Slight wind	Very low	do	Farmstead; pasture.
Pentz loam:															
Rolling and hilly	Pa	8-25	Grayish-brown or dark grayish-brown; acid; friable.	Lighter colored, friable, medium to slightly acid loam.	Light-gray or pale-brown, shaly or fine-grained tuffaceous sandstone.	Moderately shallow; variable.	Moderate	Moderate	Medium to rapid	do	Moderate	Moderate	Moderate	Relatively difficult	Annual grasses; pasture.
Steep	Pb	25+	do	do	do	Shallow; variable	do	do	Very rapid	do	Low	High	Low	Very difficult	Do.
Pentz-Redding gravelly loams:															
Rolling and hilly	Pc	8-25	Complex of Pentz and Redding soils as described elsewhere in table			Variable	do	do	Medium to rapid	do	Low to moderate	Moderate to high	Moderate to low	do	Do.
Steep	Pd	25+	do			do	do	do	Very rapid	do	do	Very high	do	Very difficult	Do.
Undulating	Pe	3-8	do			do	do	do	Slow to medium	do	do	Slight	do	Difficult	Do.
Pentz sandy loam:															
Rolling and hilly	Pf	8-25	Grayish brown; friable; neutral to medium acid.	Grayish-brown or light brownish-gray, friable sandy loam.	Light-gray or pale-brown, tuffaceous, softly consolidated sandstone.	Moderately shallow; variable.	Rapid	Rapid	Medium	do	Low	Moderate	Low	Relatively difficult	Do.
Steep	Pg	25+	do	do	do	Shallow; variable	do	do	Rapid to medium rapid.	do	do	High	do	Very difficult	Do.
Perkins gravelly loam, very gently undulating.	Ph	0-3	Brown or light-brown; slightly acid; friable.	Reddish-brown, compact, slightly acid gravelly heavy clay loam.	Stratified old gravelly alluvial material from mixed rock sources.	Moderately deep	Moderate	Slow	Very slow to slow	do	Moderate	Slight	Moderate	Relatively difficult	Dry-farmed grain; irrigated crops.
Peters clay (adobe), rolling and hilly.	Pk	8-25	Dark gray or dark grayish-brown; slightly acid; blocky.	Dark-gray to olive-gray, neutral to slightly acid clay.	Olive-gray or light-gray, softly consolidated, shaly sedimentary rock.	Moderately deep; variable.	Very slow	Very slow	Medium to rapid	do	do	do	do	do	Annual grasses; pasture.
Placer diggings	Pl	-------	Areas disturbed to relatively shallow depth, and generally gravelly or stony as a result of mining operations for placer gold												Sparse grasses.
Redding cobbly loam, undulating	Ra	3-8	Reddish-brown or light reddish-brown; acid; slightly hard when dry.	Reddish-brown or brown, very compact, acid, cobbly clay over hardpan.	Gravelly and cobbly old mixed alluvium of varying degrees of consolidation.	Shallow	Moderate	Very slow	Slow to medium	None	Low	Slight	Low	Very difficult	Annual grasses; scattered oaks and digger pines.
Redding gravelly loam, undulating and rolling.	Rb	2-15	do	Red to reddish-brown very compact acid gravelly clay over hardpan.	do	Shallow; variable	do	do	do	do	do	Moderate	do	Relatively difficult	Relatively sparse annual grasses.
Riverwash	Rc	-------	Stream-deposited sand, gravel, and cobblestones; subject to annual flooding and deposition												Very sparse grasses.
Rydberg loam, very gently sloping.	Rd	0-3	Light-gray or light brownish-gray; acid; friable.	Light-gray, light brownish-gray, or very light-gray, acid, friable loam or very fine sandy loam.	Stratified sandy materials overlying unrelated, softly consolidated sedimentary rocks.	Deep; variable	Moderate	Moderate	Very slow	None	Moderate	None	Low	Easy	Annual grasses; pasture.
Sacramento silty clay loam:															
Nearly level	Sa	0-1	Dark-gray; neutral; friable; high in organic matter.	Dark-gray, mottled, slightly basic, silty clay loam or clay loam.	Gray or dark-gray, mottled, slightly stratified basin alluvium.	Deep	do	Slow	do	Frequent	High	do	High	do	Wide range of field and truck crops.
Overflowed, nearly level	Sb	0-1	do	do	do	do	do	do	do	do	do	Periodic overflow	do	do	Pasture, field crops.
San Joaquin loam-Alamo clay (adobe), very gently undulating.	Sc	0-3	Complex of San Joaquin loam and Alamo clay (adobe) the principal characteristics of which are given under the descriptions of respective soils.			Moderately shallow	Variable	Very slow	Slow to very slow	None	Moderate	Negligible	Low	Difficult	Mainly dry-farmed grain and pasture.
San Joaquin loam:															
Deep, undulating	Sd	3-8	Brown or reddish-brown acid; moderately hard when dry.	Brown or reddish-brown, moderately compact, acid sandy clay or clay.	Light reddish-brown moderately compact old alluvium.	Deep	Moderate	Slow	Slow to medium	do	do	Slight	do	Easy	Dry-farmed grain; various irrigated crops.
Undulating	Se	3-8	do	Brown to grayish-brown, neutral to slightly basic, heavy clay loam or clay over hardpan.	Old alluvium of variable degrees of consolidation.	Moderately shallow; variable.	do	Very slow	do	None	Low	do	do	Relatively difficult	Mainly dry-farmed grain and pasture.
Very gently undulating	Sf	0-3	do	do	do	do	do	do	Slow	do	do	Negligible	do	Easy	Do.
San Joaquin sandy loam:															
Deep, undulating	Sg	3-8	Light-brown or reddish-brown; acid; moderately hard when dry.	Reddish-brown or red, moderately compact, acid sandy clay or clay.	Reddish-brown or red moderately compact old alluvium.	Deep	do	Slow	Slow to medium	do	Moderate	Slight	do	do	Mainly dry-farmed grain.
Undulating	Sh	3-8	do	Brown or reddish brown, compact, neutral clay over hardpan.	Partially consolidated old mixed alluvium.	Moderately shallow; variable.	do	Very slow	do	do	Low	do	do	Relatively difficult	Do.
Very gently undulating	Sk	0-3	do	do	do	do	do	do	Very slow to slow	do	do	Negligible	do	Easy	Dry-farmed grain; strawberries; other crops.
Scabland	Sl	-------	Very stony basaltic or andesitic lava or mud flow material			Very shallow									Sparse grasses.
Siskiyou-Holland sandy loams:															
Rolling and hilly	Sm	8-25	Grayish-brown or brown; slightly acid; rock outcrops.	Slightly acid sandy loam; lighter colored than surface.	Granitic bedrock; variable degrees of weathering.	Moderately shallow	Rapid	Rapid	Medium to rapid	None	Low	Moderate to high	Low	Difficult	Scattered oaks and grasses; pasture; some orchard fruits.
Stony and steep	Sn	25+	Grayish-brown or brown, slightly acid sandy loam; much rock outcrop.	Stony slightly acid sandy loam; lighter colored than surface.	do	do	do	do	Rapid to very rapid.	do	Very low	High	do	Very difficult	Scrub oaks, brush, and grasses; pasture.
Slickens	So	-------	Reddish-brown clay material deposited from muddy waters of dredging and hydraulic mining operations												Variable agricultural use.
Tailings	Ta	-------	Gravel and cobbles deposited in mounds or heaps from dredging and hydraulic mining operations												No agricultural use.
Terrace breaks, Redding-Corning soil materials, steep.	Tb	25+	Gravelly or cobbly slopes at the edges of old alluvial terraces												Scattered oaks; sparse grasses; pasture.
Whiterock stony loam:															
Rolling and hilly	Wa	8-25	Light brownish-gray or pale-brown; acid; rock outcrops.	None present	Gray slate with nearly vertical cleavage planes.	Very shallow	Moderate		Medium to rapid	None	Very low	Moderate	Low	Difficult	Scrub oaks and grasses or grasses alone; pasture.
Steep	Wb	25+	Light brownish-gray or pale-brown; acid; more rock outcrops than rolling and hilly soil.	do	do	do	do		Very rapid	do	do	High	do	Very difficult	Do.
Whitney fine sandy loam:															
Deep, undulating and rolling.	Wc	3-15	Brown or light reddish-brown; slightly to strongly acid; friable.	Reddish-brown moderately compact sandy clay loam.	Unconsolidated materials underlain by softly consolidated sedimentary rock.	Moderately deep	do	Moderate	Slow to medium	do	Moderate	Slight	Moderate	Easy	Orchard and field crops.
Rolling and hilly	Wd	8-25	Light-brown or reddish-brown; slightly to strongly acid; friable.	Similar or slightly redder than the surface soil; in places finer textured.	Light or reddish-colored, softly consolidated clayey or sandy sedimentary rock.	Moderately shallow	do	do	Medium to rapid	do	do	Moderate	do	Relatively difficult.	Dry-farmed grain; various irrigated crops including citrus.
Steep	We	25+	do	do	do	Shallow	do	do	Very rapid	do	Low	High	do	Very difficult	Oaks and grasses.
Undulating	Wf	3-8	Light-brown or reddish-brown; slightly or moderately acid friable fine sandy loam; in places slightly redder.	Similar to surface soil; in places slightly finer textured; resting on compact clayey material.	do	Moderately shallow to moderately deep.	do	do	Slow to medium	do	Moderate	Slight	do	Easy	Mainly dry-farmed grain.
Whitney gravelly sandy loam, rolling.	Wg	8-15	Brown, pale brown, or light brown; slightly to medium acid; friable.	Light-brown gravelly sandy loam or gravelly loam.	Softly consolidated sandstone and conglomerate.	Moderately shallow	Rapid	Rapid to moderate	Medium	do	Low	Moderate	Low	Relatively difficult.	Orchard and field crops.

[1] Soil depth refers to the depth of soil readily penetrated by roots above claypan, hardpan, bedrock, or other layer in the soil that would stop or hinder root penetration. Very shallow is less than 10 inches, shallow 10 to 20 inches, moderately shallow 20 to 36 inches, moderately deep 36 to 60 inches, and deep more than 60 inches.

[2] The term "permeability" as here used refers to the rate at which water can pass downward through the soil, which is considered a general indication of the ease of root penetration. Slow permeability may be a rate of less than 3 surface inches of water a day (24 hours), whereas rapid permeability may be a rate of 120 or more surface inches a day. A surface inch of water corresponds to water an inch deep over any given surface; it is the same measure as that used in measuring rainfall. A soil of moderate permeability in both surface and subsoil is usually ideal for irrigation. For soils of rapid permeability, irrigation basins should be small or field ditches short and head of water relatively high; and for soils of slow permeability, irrigation basins should be larger or field ditches longer and head of water relatively low. Care should be taken not to overirrigate rapidly permeable soils nor soils with surface soils of moderate or rapid permeability overlying subsoils of slow or very slow permeability.

[3] The occurrence of high water table refers to the natural occurrence within 4 feet of the surface of the soil at time of survey.

[4] Available water-holding capacity refers to the total quantity of water available to plants to a depth readily penetrated by roots when the soil is at normal field moisture capacity, approximately the moisture content of a well-drained soil 2 or 3 days after wetting. In general, soils with water-holding capacities of less than 4 surface inches are considered low, and those with capacities of 9 or more surface inches of water are considered high. Although clay soils normally have a relatively high water-holding capacity per unit mass of soil, much of the water is not available. Similarly, a very shallow clay soil would have a low or very low available water-holding capacity because of the relatively small mass of soil available for roots. Soils with low capacities require irrigation with rather small amounts of water frequently, whereas those with high capacities can be irrigated with relatively large quantities of water infrequently. Dry soils of high capacities require heavy applications of water to obtain adequate moisture penetration.

[5] Erosion hazard means the probable susceptibility of the soil to erosion if and when cultivated or heavily grazed It refers both to wind drifting and to erosion by water. Also considered under this heading are soils subject to periodic overflow unless protected by levees.

[6] Natural fertility refers to the natural ability of a soil to provide the proper plant nutrients in the proper quantities and in the proper balance for the growth of general crops, when other factors such as light, temperature, moisture, and physical conditions of the soil are favorable. Differences in natural fertility as shown in the table are purely relative and general, and do not necessarily indicate differences for specific crops or plants.

[7] Workability refers to the relative quantity of work required to till or level the land and the relative feasibility of handling farm machinery.

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TABLE 6.—*Relative suitability of soils for general intensive agriculture and for principal crops in the Sacramento Area, California*

Soil	Irrigated													Not irrigated	
	Almonds	Plums and prunes	Pears	Olives	Grapes	Truck crops	Alfalfa	Sugar beets	Beans, dry	Grain sorghum	Rice [1]	Small grains	Pasture, Ladino clover	Small grains	Pasture, range
CLASS 1.—SOILS WELL SUITED TO GENERAL INTENSIVE AGRICULTURE															
Subclass 1A:															
Columbia fine sandy loam, nearly level	Very good	Very good	Very good	Very good	Very good	Very good	Very good	Very good	Very good	Very good	Fair	Very good	Good	Good	Good.
Columbia silt loam, nearly level	do	do	do	do	do	do	do	do	do	do	Good	do	Very good	Very good	Very good.
Hanford loamy fine sand, nearly level	do	do	Good	do	do	do	Good	Good	Good	Good	Poor	Good	Fair	Fair	Good.
Hanford very fine sandy loam, nearly level	do	do	Very good	do	do	do	do	Very good	Very good	Very good	Fair	Very good	Good	Good	Do.
Honcut very fine sandy loam, nearly level	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Honcut loam, nearly level	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Subclass 1B:															
Columbia fine sandy loam:															
(Over Sacramento silty clay loam), nearly level.	do	do	do	do	do	Very good	do	Very good	do	do	Good	Very good	do	do	Do.
(Over Freeport clay), nearly level	Fair	do	Good	Good	Good	do	Good	do	do	do	do	do	do	do	Do.
Columbia silt loam:															
(Over Sacramento silty clay loam), nearly level.	Good	do	Very good	do	do	do	Very good	do	do	do	do	do	do	Very good	Very good.
(Over Freeport clay), nearly level	Fair	do	Good	do	do	do	Good	do	do	do	do	do	do	do	Do.
CLASS 2.—SOILS MODERATELY WELL SUITED TO GENERAL INTENSIVE AGRICULTURE															
Subclass 2A:															
Columbia loamy fine sand, nearly level	Good	Good	Fair	Good	Good	Good	Good	Good	Good	Good	Poor	Good	Fair	Fair	Good.
Honcut gravelly loam, nearly level	do	do	do	do	do	Fair	do	Fair	do	do	Fair	do	Very good	do	Do.
Rydberg loam, very gently sloping	do	Fair	do	do	Fair	do	do	do	Fair		do	do	Good	do	Do.
Subclass 2B:															
Chualar gritty clay loam, nearly level	Fair	do	Good	Fair	Good	do	do	Good	Good	do	Good	do	do	Good	Do.
Chualar gritty loam, very gently sloping	Good	Good	Very good	Very good	Very good	Good	Very good	Good	Very good	Very good	Fair	Good	Very good	do	Do.
Columbia fine sandy loam, overflowed, nearly level.	Variable suitability for crops depending on frequency of overflow [2]														Do.
Columbia loamy fine sand (over Freeport clay), nearly level.	Fair	Fair	Good	Fair	Good	Good	Good	Good	Good	Good	Poor	Good	Fair	Fair	Do.
Columbia silty clay:															
Over Sacramento silty clay, nearly level	do	do	do	do	Fair	do	do	do	Very good	Very good	Very good	Very good	Good	Very good	Very good.
Over Freeport clay, nearly level	Poor	Poor	Fair	Poor	do	do	do	do	do	do	do	do	do	do	Do.
Columbia silt loam, overflowed, nearly level	Variable suitability for crops depending on frequency of overflow [2]														Do.
Hanford loamy fine sand, overflowed, nearly level.[2]	do														Good.
Hanford very fine sandy loam, overflowed, nearly level.[2]	do														Do.
Honcut loam, overflowed, nearly level [2]	do														Do.
Honcut very fine sandy loam, overflowed, nearly level.[2]	do														Do.
Sacramento silty clay loam, nearly level	Poor	Poor	Fair	Poor	Fair	Very good	Good	Very good	Very good	Very good	Very good	Very good	Good	Very good	Very good.
Subclass 2C:															
Honcut loam (over San Joaquin hardpan substratum), nearly level.	Fair	Fair	do	Fair	Good	do	do	Good	do	do	Good	do	Very good	Good	Good.
Perkins gravelly loam, very gently undulating.	do	do	do	do	Fair	Fair	do	Fair	Good	Good	Fair	Good	do	Fair	Fair.
San Joaquin loam, deep, undulating	do	do	do	do	do	Good	Fair	do	do	Fair	Poor	do	Good	do	Do.
Whitney fine sandy loam:															
Undulating	do	do	do	do	do	Fair	do	do	do	do	do	do	do	do	Do.
Deep, undulating and rolling	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
CLASS 3.—SOILS ONLY FAIRLY WELL SUITED TO GENERAL INTENSIVE AGRICULTURE															
Subclass 3A:															
Oakley sand, undulating	Fair	Poor	Poor	Fair	Fair	Fair	Fair	Poor	Fair	Poor	Very poor	Fair	Poor	Poor	Fair.
Oakley loamy fine sand (over Glann loam), undulating.	Poor	do	do	Poor	do	Good	Good	Fair	do	Fair	Fair	do	Good	Fair	Good.
Subclass 3B:															
Burns silty clay loam, nearly level	Very poor	Very poor	Very poor	Very poor	Very poor	Very good	Fair	Good	Good	Good	do	do	Fair	do	Do.
Subclass 3C:															
Chualar gritty loam, channeled, very gently sloping.	Fair	Fair	Fair	Fair	Fair	Fair	do	Fair	Fair	Fair	Poor	do	Good	do	Do.
Columbia loamy fine sand:															
Channeled, nearly level	do	do	do	do	do	do	do	do	do	do	do	do	Fair	do	Do.
Overflowed, nearly level	Variable suitability for crops depending on frequency of overflow [2]														Do.
Columbia fine sandy loam, channeled, nearly level.	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Good	Fair	Poor	Fair	Good	Fair	Do.
Columbia silty clay (over Sacramento silty clay), overflowed, nearly level.	Variable suitability for crops depending on frequency of overflow														Very good.
Hanford loamy fine sand, channeled, nearly level.	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Fair	Fair	Fair	Good.
Hanford very fine sandy loam, channeled, nearly level.	do	do	do	do	do	Good	do	do	Good	do	do	do	Good	do	Do.
Honcut loam, channeled, nearly level	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Sacramento silty clay loam, overflowed, nearly level.	Variable suitability for crops depending on frequency of overflow [2]														Very good.
Slickens	Variable suitability for crops depending on character of underlying material														Good.
Subclass 3D:															
Holland sandy loam, rolling and hilly	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Fair	Poor	Very poor	Poor	Fair	Fair	Do.
Pentz sandy loam, rolling and hilly	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Pentz loam, rolling and hilly	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
San Joaquin sandy loam, deep, undulating	do	do	do	do	do	Good	do	Fair	do	do	Poor	Fair	Good	do	Fair.
Whitney fine sandy loam, rolling and hilly	do	do	do	do	do	Fair	do	Poor	do	do	Very poor	Poor	Fair	do	Good.
CLASS 4.—SOILS POORLY SUITED TO GENERAL INTENSIVE AGRICULTURE															
Subclass 4A:															
Alamo clay (adobe), nearly level	Very poor	Very poor	Very poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Fair	Fair	Fair	Good.
Bear Creek gravelly loam, very gently sloping	Poor	Poor	Poor	do	Fair	do	do	do	Fair	do	do	do	Good	do	Do.
Corning gravelly loam, undulating	do	do	do	do	Poor	do	do	do	Poor	do	Poor	Poor	Fair	do	Fair.
Freeport clay (adobe), nearly level	Very poor	Very poor	do	Very poor	do	Fair	do	do	Fair	Fair	Fair	Good	Good	Good	Good.
Glann loam, nearly level	do	do	do	do	do	do	do	do	Good	Good	do	do	Very good	do	Do.
Hanford sand, overflowed, nearly level	Variable suitability for crops depending on frequency of overflow														Fair.
Honcut very fine sandy loam (over Bear Creek gravelly loam), overflowed, very gently sloping.	do														Good.
Kitchen middens	Variable suitability for crops depending on character of underlying material														Do.
Pentz-Redding gravelly loams, undulating	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Fair.
Redding gravelly loam, undulating and rolling.	do	do	do	do	do	do	do	do	do	do	do	do	do	Fair	Do.
San Joaquin sandy loam:															
Very gently undulating	do	do	do	do	Fair	Fair [3]	do	do	do	do	Fair	Fair	Good	do	Do.
Undulating	do	do	do	do	do	Fair	do	do	do	do	Poor	do	Fair	do	Do.
San Joaquin loam:															
Very gently undulating	do	do	do	do	do	do	do	do	Fair	do	Fair	do	Good	do	Do.
Undulating	do	do	do	do	do	do	do	do	Poor	do	Poor	do	Fair	do	Do.
San Joaquin loam—Alamo clay (adobe), very gently undulating.	Very poor	Very poor	Very poor	do	Poor	Poor	do	do	do	do	Fair	do	do	do	Do.
Subclass 4B:															
Auburn stony loam:															
Rolling and hilly	Poor	Poor	Poor	do	do	do	do	Very poor	do	do	Very poor	Poor	Poor	Poor	Do.
Undulating	do	do	do	do	do	do	do	do	do	do	do	do	Fair	do	Good.
Ayar clay loam, rolling and hilly	do	do	do	do	do	do	do	do	do	do	do	do	do	Fair	Do.
Pentz-Redding gravelly loams, rolling and hilly.	do	do	do	do	do	Very poor	do	do	Very poor	Very poor	do	do	do	Poor	Fair.
Peters clay (adobe), rolling and hilly	do	do	do	do	do	Poor	do	do	Poor	Poor	do	do	do	Fair	Good.
Siskiyou-Holland sandy loams, rolling and hilly.	do	do	do	do	do	do	do	do	do	do	do	do	Poor	Poor	Fair.
Whitney gravelly sandy loam, rolling	do	do	do	do	do	do	do	do	do	do	do	do	Fair	Fair	Do.
CLASS 5.—SOILS VERY POORLY SUITED TO GENERAL INTENSIVE AGRICULTURE															
Subclass 5A:															
Amador fine sandy loam:															
Rolling and hilly	Very poor	Very poor	Very poor	Poor	Poor	Very poor	Poor	Very poor	Very poor	Very poor	Very poor	Poor	Poor	Poor	Poor.
Undulating	Poor	Poor	Poor	do	do	Poor	do	Poor	Poor	Poor	do	do	do	do	Fair.
Dorado stony silt loam, rolling and hilly	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	do	Very poor	do	Very poor	Do.
Pentz sandy loam, steep	do	do	do	do	do	do	do	do	do	do	do	do	Very poor	do	Poor.
Pentz loam, steep	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Redding cobbly loam, undulating	do	do	do	do	do	do	do	do	do	do	do	do	Poor	do	Do.
Whiterock stony loam, rolling and hilly	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Fair.
Whitney fine sandy loam, steep	do	do	do	do	do	do	do	do	do	do	do	do	Very poor	do	Poor.
CLASS 6.—NONAGRICULTURAL SOILS AND LAND TYPES															
Subclass 6A:															
Amador fine sandy loam, steep	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor.
Auburn stony loam, steep	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Fair.
Dorado stony silt loam, steep	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Poor.
Pentz-Redding gravelly loams, steep	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Siskiyou-Holland sandy loams, stony and steep.	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Terrace breaks (Redding-Corning soil materials), steep.	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Whiterock stony loam, steep	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Subclass 6B:															
Placer diggings	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Riverwash	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Very poor.
Scabland	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.
Tailings	do	do	do	do	do	do	do	do	do	do	do	do	do	do	Do.

[1] Where suitability for rice is stated as "very good", only soil located in the American Basin is so considered.

[2] Suitability for hops "fair" to "good."

[3] Suitability for strawberries "good."